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INTRODUCTION.

As explained in this Introduction during 1914 the MONTHLY WEATHER REVIEW now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The MONTHLY WEATHER REVIEW contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports of climatological data for the respective States, Territories, and colonies.

Since December, 1914, the material for the MONTHLY WEATHER REVIEW has been prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology.*—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology.*—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere.*

SECTION 4.—*Rivers and floods.*

SECTION 5.—*Seismology*—Results of observations by Weather Bureau observers and others as reported to the Washington office. Occasional original papers by prominent students of seismological phenomena.

SECTION 6.—*Bibliography.*—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 7.—*Weather of the month.*—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation; data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto.

In general, appropriate officials prepare the seven sections above enumerated; but all students of atmospherics are cordially invited to contribute such additional articles as seem to be of value.

The voluminous tables of data and text relative to local climatological conditions that during recent years were prepared by the 12 respective "district editors," are omitted from the MONTHLY WEATHER REVIEW, but collected and published by States at selected sections centers.

The data needed in Section 7 can only be collected and prepared several weeks after the close of the month whose name appears on the title page; hence the REVIEW as a whole can only issue from the press within about eight weeks from the end of that month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are especially due to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.

The Central Meteorological and Magnetic Observatory of Mexico.

The Director General of Mexican Telegraphs.

The Meteorological Service of Cuba.

The Meteorological Observatory of Belen College, Habana.

The Government Meteorological Office of Jamaica.

The Meteorological Service of the Azores.

The Meteorological Office, London.

The Danish Meteorological Institute.

The Physical Central Observatory, Petrograd.

The Philippine Weather Bureau.

The General Superintendent United States Life-Saving Service.

SECTION I.—AEROLOGY.

THE DIURNAL PERIOD OF THE WIND VELOCITY.

During 1912 and 1913 Prof. G. Hellmann (1) has studied the vertical change in wind velocity in winds up to moderate distances above the earth's surface. These studies have helped to reach the following conclusions concerning the diurnal periods of the velocity at different levels.—C. A., jr.

When one reviews all the facts heretofore learned concerning the diurnal period of the wind velocity, supplementing them with those brought out [in (1)], one comes to hold the view that the principal wind phenomenon of the higher levels of the atmosphere demanding explanation is the diurnal period.

In our region of the globe, viz, that of the prevailing westerlies, the diurnal period in the wind velocity, characterized by a nocturnal maximum and a daytime minimum, dominates the greater mass of the atmosphere. Throughout the year this diurnal period extends down to the surface of the ocean; but over the lands it extends only to within about 50 meters of their surface during the cold season and to within about 100 meters during the warm season, and with weak air movements down to within a few meters of the ground. Inversely, that diurnal period of the wind velocity characterized by a daylight maximum and a nocturnal minimum, is restricted to the corresponding lowermost atmospheric layers and in fact is found in all the wind districts of the land regions of the earth.

The Espy-Köppen theory, which is the most widely known, seeks to explain both types of the diurnal periodicity in the wind velocity by the effect of the ascending and descending air currents that develop over the continents during the day. The ascending currents weaken the higher lying air currents; the descending currents bring down from above more rapidly moving air and thereby increase the wind velocity of the lower strata.

Such convection currents are indeed adequate to explain the processes taking place in the lower air layers. It has, however, long been recognized as a fault in this theory that the daytime minimum in the wind velocity which occurs even during the winter at great altitudes, could scarcely be due to ascending air currents. To be sure, our knowledge of these upper air conditions is almost wholly due to observations at mountain stations, that is, at points on the earth's surface. A. Peppler's recent effort to use wind-velocity observations made by means of kites in deducing the period for the free-air winds has taught us, however, that here also the velocity minimum seems to occur during the daytime. The conclusion is still somewhat uncertain, since the measurements are numerically few and very unequally distributed among the different hours. On the other hand, the records secured from the summit of the Eiffel Tower (305 meters) are altogether in favor of the conclusion that the general character of the diurnal period of the wind velocity is the same for mountain summits as for the upper strata of the free air (**2**).

The writer finds that the cause of the diurnal period in the air currents of the main portion of the atmosphere, lies in the thermal wave which passes around the earth from east to west every 24 hours; a phenomenon which has already been pointed out, sometimes in quite different connections, by Kelvin, Margules, Gold, Möller, and others. In the morning the air of the more easterly regions is more strongly heated, thereby the isobaric surfaces in the east suffer elevation so that an overhead pressure gradient from east to west arises. The prevailing west wind must thereby be weakened, while after the thermal wave has crossed a given local meridian both the causes have the same sign and therefore tend to strengthen the wind velocity. For a locality in the Northern Hemisphere the region of maximum heating and the summit of the resultant great air wave, lies to the southeast in the morning, to the south at noon, and to the southwest in the afternoon, so that the resultant of the two effective forces must vary according as the general westerly drift of the air of the higher atmosphere inclines to come from the northwest, west, or southwest.

Is this view correct, then it may be expected that districts having predominantly east winds will have a diurnal period the opposite of the above, i. e., a daytime maximum. This is in fact the case. We have for some time known the remarkable fact that on the summits of the mountains of the southern East Indies the diurnal period of the wind velocity during the dominance of the southwest monsoon is similar to that of our own mountains (**3**); but that during the northeast monsoon the diurnal period is inverted, showing a daytime maximum. In these cases then, both the upper and the lower strata have the same hourly changes in wind velocity.

Our hypothesis gives, at the same time, an explanation of the fact that in the portion of the region of the northeast trades lying over the continents (northern Africa, northern South America), there is such a pronounced daily period to the wind velocity that the wind becomes almost stormy soon after noon while in the evening it sinks to a complete calm.

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Also, Sitzber., K. preuss. Ak. d. Wissens., Phys.-math. Kl., 1914, Apr. 2. pp. 415-437. [Reprinted.]

(2) **Hann, J.** Der tägliche Gang der Windstärke auf dem Gipfel von Ben Nevis und seine Bedeutung für die Theorie. Met. Ztschr., 1912, **29**: 462.

(3) **Hann, J.** Die täglich Variation der Windstärke auf den Berggipfeln in Südindien. Met. Ztschr., 1898, **15**: 220. See also **his** Lehrbuch der Meteorologie. Leipzig, 1915. 3d. ed., p. 410.

THE ASCENT OF AIR ABOVE ACTIVE VOLCANOES.

By Dr. KURT WEGENER, Göttingen.

[Translated from "Gerlands Beiträge zur Geophysik," Leipzig, v. 11, 1912, Kl. Mitt. p. 136-139.]

Besides the alarming eruption of glowing or hot lava fragments that accompanies a volcanic eruption, there is a second phenomenon that often is not less striking in external splendor and always furnishes an effective background for the former display, and that is the columns of steam rising above the crater and frequently sending down lightning, thunder, and rain.

So far as I am able properly to understand the portion of vulcanological literature known to me, students are to-day inclined to regard the enormous masses of water carried up into the air to descend again as rain, as being in whole or in part "juvenile water," that is water which was united with the glowing lava and had separated out as vapor as the lava cooled.

Delkeskamp [1] has found it probable that glowing lava quiescent at a depth within the earth's crust has a water-content of 10 per cent. According to this I had expected a volcano or a lava spring would develop a quantity of vapor proportionate to the amount of lava extruded and cooled.

In near-by Savaii (Samoa) an overflowing lava spring formed a lava field about 40 km² in extent and of an average depth of 5 meters. Hence in 1906 and 1907 about 200,000,000 cubic meters of lava were poured out, which would have brought 20,000,000 cubic meters of water vapor into the air, assuming a water content of 10 per cent. This would be a large volume as compared with that delivered by other known volcanoes, yet the columns of steam and "smoke" in Savaii were actually rather slight as is the case with many lava lakes. According to the reports of those living near the Savaii lake the steam and "smoke" columns were best developed during the first year of the eruption, viz, 1905. But at that time no noteworthy volume of lava overflowed at all, there being but explosions which tossed the lava into the air.

These experiences seem to me to justify one in doubting whether the steam cloud consists altogether or even largely of juvenile water.

On the other hand one can not immediately deny the presence of juvenile water in the lava, due either to water primarily in the lava or to water from the earth's surface which has in some way penetrated to the liquid lava. Only scattered students seem to hold the latter view. It seems thus to be of interest to consider whether and to what extent the juvenile water is necessary in order to explain the development of the vapor column, as also what rôle purely meteorological processes might play here.

When the air resting upon the margins of a crater (Kraterrand) becomes heated it expands, thereby becomes (specifically) lighter than its surroundings and ascends. The cooling due to ascension and expansion (1° C. per 100 meters for dry air) will sooner or later cause condensation and thunderstorms in proportion to the moisture content of the air, which varies between 4 grams per cubic meter in temperate latitudes and 18 grams per cubic meter in the Tropics. For the sake of simplicity suppose that the crater has an altitude of several hundred meters so that 1 kilogram of air has the volume of 1 cubic meter of air. Assume that the temperature of the air is 20° C., which is approximately that of tropical and subtropical latitudes. Further take the amount of water contained in 1 kilogram of air as being 14 grams; at saturation it would be 16 grams.

Now the pronounced stratification of our atmosphere will prevent the warmed air rising to very great altitudes, in individual cases, unless there were very strong heating at the volcano. The degree of heating at the volcano will, however, rarely exceed a certain normal amount since a definite ascensional force, *alias* heating, of the air would carry it away from the further influence of the volcano. Thus the altitudes to which ascending air may attain and accordingly the intensity of the thunderstorm concomitantly developed, will both depend upon the atmospheric conditions as will also the general effect made by the erupting crater. Many craters will not be able to develop their clouds beyond altitudes of 3,000 to 4,000 meters where the steam cloud will have to spread out along the boundary of the limiting stratum that generally lies at that altitude. Most ascending currents over volcanoes will have ceased to ascend when they have attained an altitude of from 10,000 to 15,000 meters, where begins a third meteorologically important stratum whose temperature is relatively notably higher than that of the currents beneath it. It is in rare cases only, including particularly the recent explosion of Krakatoa, that the ascending air masses with their accompanying load of gas, lava, and dust particles are able to effect a notable penetration into this third stratum.

The temperature of a volume of air ascending adiabatically, i. e., without receiving heat from its surroundings, decreases at rates lying between 1°C. and 0.5°C. per 100 meters. Hence the separation from it of its water content. In general the temperature of the free-air strata decreases upward at the same rate of 0.5° to 1.0°C. per 100 meters. At the boundaries of the air layers, however—and the meteorologically most important lie at about 4,000 and 10,000 meters—there is often a sudden change in temperature such that, on the average, the overlying stratum is *relatively warmer* than the underlying stratum. Such a stratification wherein warmer, hence lighter air, overlies colder air is mechanically stable and opposes the further ascent of the rising air.

If it be assumed that the air ascends to an altitude of 10 or 15 kilometers then the dynamic cooling must have caused the liquefaction of practically all its content of water vapor. It would be followed by other air masses ascending and cooling under the same conditions. If the ascensional velocity of the air is 1 meter per second then over an area of 1 square meter of the earth's surface there will be set free every second 14 grams = 0.014 kilogram of moisture, or 0.84 kilogram every minute.

Balloon observations have shown us that an ascensional velocity of 10 meters per second is no rarity for the air over the sun-warmed portion of the earth. It is certain that the air over craters is much more strongly heated than elsewhere and acquires a greater upward tendency.

However, we may stick to the above ascensional velocity for the present and regard a velocity of 10 meters per second as the lower limiting value. The resulting production of rainwater would be 8.4 kilograms per minute per square meter of the crater surface $\left(=8.4\frac{\text{kg.}}{\text{min.m}^2}\right)$.

Hellmann's well-known work on the rainfall of the river basins of northern Germany (vol. 1, p. 157) gives the absolute maximum rainfall for a brief interval as $4\frac{\text{mm.}}{\text{minute}}=\frac{4\text{ kg.}}{\text{min. m}^2}$ for Germany. In the Tropics the water vapor content of the atmosphere is about four or five times as great as it is in Germany; so that a measured rainfall of $\frac{8.4\text{ kg.}}{\text{min. m}^2}$ would not be extraordinary. As a matter of fact, however, the actually measured rainfall can be but a fraction of the water produced. A larger and perhaps the greater portion of the water produced remains as clouds floating in or very slowly falling through the air. Further that portion of the produced water which reaches our gages will be spread over a many times larger area [than that from within which it originated].

[1] Der Umschau, May 26, 1906.

Thus a comparison with Hellmann's averages leads us to the conclusion that our assumptions as to ascensional velocity and moisture content are close to the lower limits of the probable ones; and that meteorological processes alone would be adequate to explain the amount of water that occurs as rain or cloud.

When the air has an ascensional velocity of 10 meters per second even thick raindrops [2] can no longer approach the earth. If they are pushed aside then it would seem as though, by reason of the sorting action of the ascending air, the mass of the drops must increase until their weight overcomes the kinetic energy of the ascending air and a violent outbreak follows. Perhaps this is the procedure in the case of the mud-flows which are reported as accompanying some volcanic eruptions.

Take for example a volcano having a chimney aperture of 10 square meters, according to the above assumptions it would yield water to the amount of $8.4\times100\times100=84,000$ liters $=84$ cubic meters per minute. This would amount to:

5×10^3 cubic meters per hour.
121×10^3 cubic meters per day.
44×10^6 cubic meters per year.

The chimney aperture of the lava lake on Savaii is approximately ten times as great as the above, hence would produce 440×10^6 cubic meters of rainwater per year while its product in juvenile water for the same period, and under the most favorable conditions, would be but 10×10^6 cubic meters or 1/44 of the total water produced—an insignificant fraction. This contrast becomes yet more striking when the extensive spread and surface of the extruded lava in Savaii are considered. For one must consider that the air ascends from over the hot lava-flow as well as from the lava lake; and that while the quantity of juvenile water exhaled remains constant, being merely spread over a greater surface, the ascending air current secures thereby an extraordinarily larger base. It would be much nearer the truth, therefore, if the amount of water brought to condensation merely as the result of warming the air, or by meteorological processes, over the Savaii lava lake were set at ten times the above-assumed quantity.[3]

As a result of the warming of the air it becomes more receptive for water vapor, and the juvenile water evaporates into it there to play a role similar to that of the natural water-vapor content of the air. The existence of the juvenile water vapor may not be denied, but the above discussion shows that it can form so small a factor in the meteorological processes involved as to be unrecognizable, and its existence is not seen to be probable except after studying other considerations. The juvenile water vapor can not appear independently. Meteorologically it can only have the significance that its presence shifts the level of condensation or the level of development of "visible" water vapor somewhat lower, at the very most bringing this level down into the chimney itself.

The occurrence of electric discharges needs no special explanation when they accompany heavy formation of cloud and has nothing to do with the crater as such.

The significance of the general weather conditions and particularly of the temporarily prevailing atmospheric stratification, has already been pointed out. The same volcano that, under well-developed stable stratification, and perhaps dry air, can drive up its cap of steam cloud, rain, or thunderstorm to an altitude of only 3,000 to 4,000 meters—thereby precipitating only about one-half of the water present as vapor—can make an extraordinarily greater impression of its activities when an almost indifferent atmospheric equilibrium permits it to drive its cloud masses to altitudes of 10,000 to 15,000 meters, whence the blue-black cap pours down a heavy, rattling rain of water, ashes, and lava fragments. In the latter case it is difficult to avoid blaming the volcanic eruption for the flash and flare of the lightning among the cloud masses, the roar of the thunder, and even the trembling of the thunder-shaken ground; as a matter of fact the relation between the volcano and the meteorological phenomena is a very loose and indirect one.

[2] There is a limit to the diameter and the speed of descent of raindrops. When their fall exceeds a certain speed they split up.

[3] So that the proportion would better read,

Juvenile water: Meteorological water :: 1 : 440.

COMMENTS.

In connection with the subject of the foregoing paper by Dr. Wegener it is instructive to recall that the Carnegie Institution of Washington has recently conducted experiments on much the same phenomena as they develop at the volcanoes of Hawaii. There is good reason for believing that the character of the activity and the nature of the volcanic products are closely similar in Hawaii and Savaii (the larger of the two islands of German Samoa). Dr. Arthur L. Day, who has been in charge of recent studies in Hawaii, finds that there the volcano cloud consists chiefly of finely divided sulphur, not of water particles, and if the same is true of the cloud at Savaii it will be necessary to modify the conclusions reached by Wegener.

At Hawaii, says Dr. Day,[4] the volatile products escape in two ways: (1) From the hot lava; and (2) from cracks in the adjacent cold lava forming the basin of the pool. When escaping from the hot lava the gases have its temperature and they burn to transparency on coming into contact with the air, so that the hydrogen forms water, the sulphur forms SO_2, and so on. When the gases are escaping from the adjacent, comparatively cold cracks, however, they are cooled before they reach the atmospheric oxygen and do not react with it, so that the hydrogen then escapes as hydrogen, and the sulphur as sulphur. During diminished activity and consequent low stages of the liquid lava, a maximum number of cracks in the cold lava are exposed so that the gases of the liquid lava mostly escape in the relatively cold condition and the visible cloud *increases*. In Hawaii this cloud appears, in fact, to be mostly free sulphur. During periods of considerable activity, on the other hand the liquid lava rises and overflows, thereby closing the cracks in the cold lava rim, and consequently reducing the volume of the visible cloud which may indeed *cease entirely*. Thus the apparent magnitude of the volcano cloud over the Hawaiian lava lakes is, roughly, in inverse proportion to the volcanic activity and so to the amount of volatile matter given off by the liquid lava. This is probably not true for explosive volcanoes, but it may hold for the Samoan localities referred to by Wegener. If there is this similarity with the Hawaiian volcanoes, then it may be necessary to modify the conclusions drawn in Wegener's paper.—[C. A. jr.]

[4] Letter to the editor, dated Washington, D. C., Mar. 27, 1915.

SECTION II.—GENERAL METEOROLOGY.

A CORRELATION OF WEATHER CONDITIONS AND PRODUCTION OF COTTON IN TEXAS.

By JOSEPH BURTON KINCER.

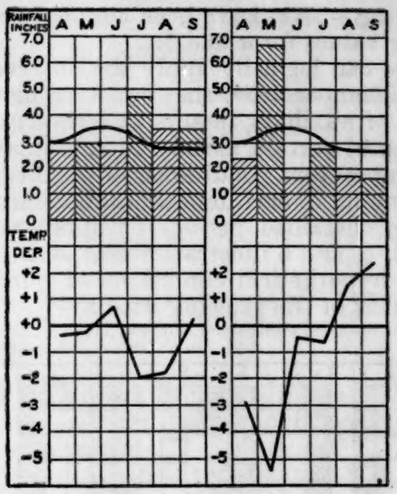
[Dated: Weather Bureau, Washington, D. C., Mar. 31, 1915.]

Every farmer, whether he be operating on progressive and scientific principles by advanced and approved methods of agriculture, or laboring under the handicaps incident to failure or refusal to adopt such methods, realizes the importance of favorable weather as a copartner, so to speak, in this the greatest and most important of all industries. Soil fertility, it is true, is an important factor in determining whether the returns shall be large or small, but it must take second place, as fertility and approved methods of cultivation would avail but little without favorable conditions as to moisture and temperature. It is also well known that in regions where the amount of rainfall and the temperature conditions are such as to ordinarily meet the requirements of plant growth, unfavorable meteorological conditions frequently occur, with a corresponding reduction in yield from what it would have been under more favorable circumstances, if not resulting in almost complete failure. In general, the more pronounced the unfavorable conditions, the greater is this reduction in yield, in view of which a direct relation between weather and crop production is obvious; but this relation had until recently been known only in a general, vague, and indefinite way and the matter had received but little consideration. However, with the advent of the new science of agricultural meteorology the importance of the question and the broad field offered by it for scientific study and investigation presented themselves so forcibly that the matter could no longer be ignored and much has been accomplished already toward establishing a physical relation between meteorology and plant development.

It is the purpose of this paper to briefly discuss this relation from a practical standpoint as applied to the production of cotton in the State of Texas, but it has been found feasible at this time to consider only the meteorological elements of precipitation and temperature, of which the former unquestionably is the more important and should receive the greater consideration.

It is realized that if certain difficulties, from a correlation standpoint, in the measuring of precipitation could be overcome, it would be preferable to consider a more limited territory as a unit area, but under present conditions it is thought best to consider the State as a whole. The usual summer type of precipitation is that of local showers, instead of comparatively uniform amounts over extended areas, as in the winter type with its pronounced cyclonic action. The summer showers frequently occur as heavy falls over limited areas in comparatively short periods of time, a large portion of which often contributes nothing to the development of the plants, but runs off and is lost, in so far as the ultimate result on production is concerned. If we attempt to correlate precipitation with yield under these conditions, ignoring the intensity of the falls and the resulting run-off, it is obvious that no reliable relation could be established, as we include in our computations varying amounts of water that flowed into the streams and rivers without contributing anything to the development of the plants. In the State of Texas these excessive local falls are, as a rule, of comparatively infrequent occurrence, and by considering the State as a whole, with its numerous reporting stations, this difficulty is largely overcome, or at least is reduced to a minimum.

We shall take as a base for computation the normal temperature and rainfall for the State, and attempt to correlate the actual departures from these mean values with the departures from the average yield of cotton, expressed in pounds per acre. The normal rainfall used in the computations represents a smoothed curve for the computed normals for the State, with monthly values as follows: April, 3 inches; May, 3.5; June, 3.5; July, 3; August, 2.8, and September, 2.8



FIGS. 1 and 2.—Shaded blocks in upper portion of diagrams show average monthly precipitation, as indicated by figures at the left, and the heavy solid lines show the normal rainfall for the respective months.

The monthly temperature departures from the normal are shown by the heavy lines in the lower part of the diagrams.

We shall assume that the greater the departures of rainfall and temperature from the normal values during the planting and growing season, covered by the months named, the smaller will be the yield of cotton. The logic of this assumption is clearly shown by a comparison of the departures of rainfall and temperature with the resulting yields for a series of years. In this connection attention is invited to figs. 1 and 2, which represent graphically the monthly rainfall and temperature departures from the normal for the State of Texas for the years 1906 and 1907, respectively. It will be noted that in 1906 the departures from the normals were small, while in 1907 they were large. The yield for the former year was 225 pounds per acre, or about 32 per cent above the average, while for the latter it was only 130 pounds per acre, or about 26 per cent below the average.

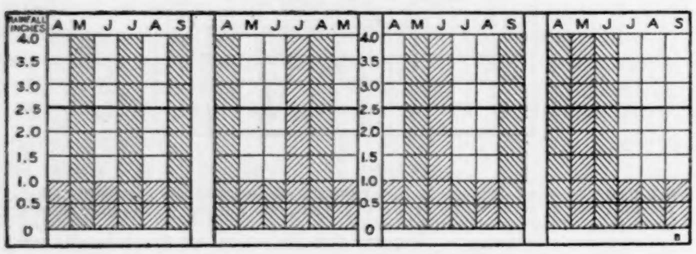
These facts give us the germ of a measurement from which a skeleton equation may be written, thus,

$$X = a + b, \qquad (1)$$

where X represents the departure of yield from the average, a the departure of rainfall, and b the departure of temperature from the normal.

However, some necessary and important modifications of this equation must be made before practical application is feasible. In the first place the normal rainfall and temperature would not produce an average yield, but, on the contrary under such conditions, the yield would be much above that value, as is clearly indicated by figure 1. Again, the first member of this equation (the departure from the average yield) may be positive or negative, depending on whether the weather conditions had been favorable or unfavorable, and this sign must be indicated for practical application. Furthermore, some unit period of time must be adopted from which to obtain values for the second member. Obviously we could not consider the departures from the normal rainfall and temperature for the season as a whole, for large values could obtain on either side of the normal for the first half of the season and equally large departures on the opposite side for the last half, which, combined, would give values for the season as a whole, equal to the seasonal normal; thus superficially indicating favorable conditions, which in fact would have been most unfavorable. In view of this the calendar months of the growing season have been adopted as unit periods for deriving values for a and b.

Before we can logically apply the observed values for rainfall and temperature, they must be modified by the assignment of auxiliary factors to represent the modifying influence of certain associated combinations of rainfall and temperature conditions, of condition of the soil at the beginning of each month, and of intensified effect due to long sustained periods of unfavorable weather. Figures 3, 4, 5, and 6 illustrate these points. These represent four hypothetical conditions of rainfall, covering the six months of the growing season.



3. 4. 5. 6.

FIGS. 3, 4, 5, 6.—Four hypothetical rainfall conditions, illustrating different distributions during the growing season as affecting ultimate production. The shaded blocks show the average monthly rainfall, as indicated by the figures at the left, and the heavy solid line indicates the normal rainfall.

In each of these cases the normal rainfall is represented as being 2.5 inches for each month, and the accumulated departure for the season as a whole is the same in each instance, the latter value being zero. A knowledge of the general effect of rainfall conditions on plant development demonstrates that the production would vary greatly for these years. They are arranged in order of their value from the standpoint of yield, figure 3 being the most favorable for the production of a large yield and figure 6 the least favorable. In the first figure we find the departures alternating from month to month, which means, for example, that each month of deficient rainfall begins with the soil well supplied with moisture, thereby ameliorating the droughty conditions; also the periods of drought are of comparatively short duration. Again each month of excessive rainfall begins with the soil comparatively dry, in which condition it can accommodate more than the usual amount of rainfall without detriment to the growing plants. In figure 4 a drought prevails in May and June, but these are the cultivating months and such condition affords excellent opportunity for thorough cultivation and assures a crop free of grass. Figure 5 indicates conditions more unfavorable; May and June are perhaps too wet for proper cultivation, while July and August present a more or less serious drought, coming in the fruiting season. Figure 6 indicates conditions obviously most unfavorable; the excessive rainfall in the first half of the season not only prevents proper cultivation, but encourages shallow root growth, which proves disastrous during the long drought to follow.

Figure 7, which was also published in the October, 1914, issue of the National Weather and Crop Bulletin, shows graphically the weekly rainfall and temperature conditions during the growing season of 1914 for the States of Texas and Oklahoma, and also the percentage of

COTTON REGION.

Western Section: Texas and Oklahoma.

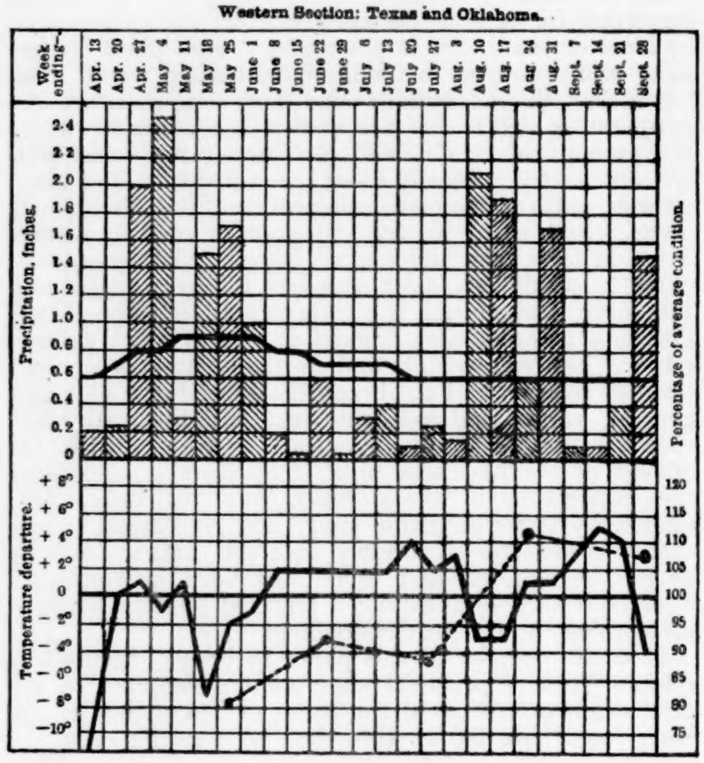


FIG. 7.—Shaded blocks in upper part of the diagram show average weekly precipitation as indicated by figures at left, and the heavy solid line indicates the normal weekly precipitation.

The weekly temperature departures from the normal are shown by the heavy black line in the lower part of the diagram, the amount of departures, in degrees, being indicated by the figures on the left. The percentage of the average condition of cotton on the dates indicated is shown by the dotted line, the amounts above or below 100 per cent being indicated by the figures on the right.

average condition of the cotton crop in those States on the 25th of the respective months from May to September, inclusive, as reported by the Bureau of Crop Estimates, Department of Agriculture. This figure very forcibly fortifies the argument that the amount of rainfall or departure from the normal for a definite period of time can not, under certain conditions, logically or practically be considered independently of preceding conditions in correlating rainfall with crop yield. The diagram shows that a more or less serious drought began the 1st of June and ended about the 1st of August, but that this drought was preceded by excessive precipitation. The accumulated minus departure of rainfall for the first four weeks of the drought, ending June 29 or four days after the June report of the crop condition, was consider-

ably greater than for the second four weeks, ending July 27 or two days after the July report of condition. Notwithstanding this larger departure for the first four weeks, the report of condition shows a substantial improvement in the crop for that period, while for the second period a considerable deterioration is noted. Considering the fact that the soil was thoroughly saturated at the beginning of the first period, with dry, warm weather needed, and that the soil moisture was largely depleted at the beginning of the second, the condition of the crop as indicated at the end of the respective periods was such as would logically be expected.

Likewise in considering temperature departures from the normal, the season in which they occur and their relation to the moisture condition for the period under consideration, as well as their duration at abnormal values, must be considered. For example, a given negative temperature departure with excessive rainfall during the spring months, e. g., May and June, would be more harmful than a like condition during a midsummer month. The temperature is normally lower and rainfall normally higher for the spring months, and this, in addition to the temperature requirement of the young plant during its early growth, renders the conditions stated more detrimental than if occurring later in the season. Still further, a positive temperature departure with deficient rainfall for the summer months is more harmful than a negative departure with like rainfall conditions, especially if the rainfall has been deficient for a considerable length of time, as excessive heat favors evaporation and thus further depletes the soil moisture.

This matter has been considered at some length to emphasize the fact that in practical application the observed values of a and b must be modified by the introduction of auxiliary factors, thus,

$$X=(ac+bc_1), \tag{2}$$

where c and c_1 represent the relative weights to be assigned to a and b. However the expression $(ac+bc_1)$ represents the departures for a single month. To obtain a value for the whole season the equation becomes,

$$X = \frac{(ac+bc_1)_1 + (ac+bc_1)_2 \ldots + (ac+bc_1)_n}{n}$$

$$= \frac{\Sigma(ac+bc_1)}{n}, \tag{3}$$

where Σ stands for the summation of all the quantities denoted by $(ac+bc_1)$, and n is the number of months in the season.

The values assigned to the auxiliary factors c and c_1, for the 20-year period, 1894 to 1913, inclusive, are given in the following tables. In Table 1 are entered the values for c, and in Table 2 those for c_1. These are of necessity arbitrarily or empirically fixed, but are assigned after a careful study of weather conditions for the period named, in conjunction with the resulting yield for the respective years, and from a general knowledge of the effect on plant development of certain combinations of weather. A careful study of the tables will disclose logical relations.

Under rainfall we can have four conditions: (1) a month of plus departure following a month of like departure; (2) a month of plus departure following a minus departure; (3) a month of minus departure following a like sign; (4) a month of minus departure following the opposite sign. The values assigned to c in each case are as follows:

TABLE 1.—*Rainfall auxiliaries; values for c.*

	Conditions.	Apr.	May.	June.	July.	Aug.	Sept.
1	+ following 0 or +	4	8	8	4	4	4
2	+ following −	4	4	2†	2†	2†	3
3	− following −*	4	5	6	8‡	10‡	8‡
4	− following 0 or +*	2	2	3	6‡	8‡	4

* Minus departures of less than 0.3 of an inch for April and May are considered as normal.

† If following 2 or more months of minus departure, substitute 1 if departure more than 1 inch; and 0 if less than 1 inch.

‡ If fourth consecutive month of minus departure, increase value by 2; fifth month by 6, and sixth month by 8; all minus departures for July and August of more than 2 inches are given a minimum value of 12.

Under temperature we can likewise have four combinations: (1) a plus temperature departure occurring with a plus rainfall departure; (2) plus temperature departure with minus rainfall departure; (3) minus temperature with minus rainfall departure; (4) minus temperature with plus rainfall departure. The values assigned to c_1 in each case are as follows:

TABLE 2.—*Temperature auxiliaries; values for c_1.*

	Conditions.	Apr.	May.	June.	July.	Aug.	Sept.
1	+ Temperature with 0 or + rainfall	1	1	1	1	1	1
2	+ Temperature with − rainfall	1	1	2†	2†	2†	1†
3	− Temperature with − rainfall ‡	1	3	2	2	2	2
4	− Temperature with + rainfall ‡	1	4	4	2	2	2

† If third month of minus rainfall increase value by 2; if the fourth, fifth, or sixth month, by 3.

‡ If third consecutive month of minus temperature departure, increase value by 1; ourth month by 2; and fifth or sixth month, by 3.

It will be noted that prolonged periods of unfavorable conditions are provided for by increased values as indicated in footnotes.

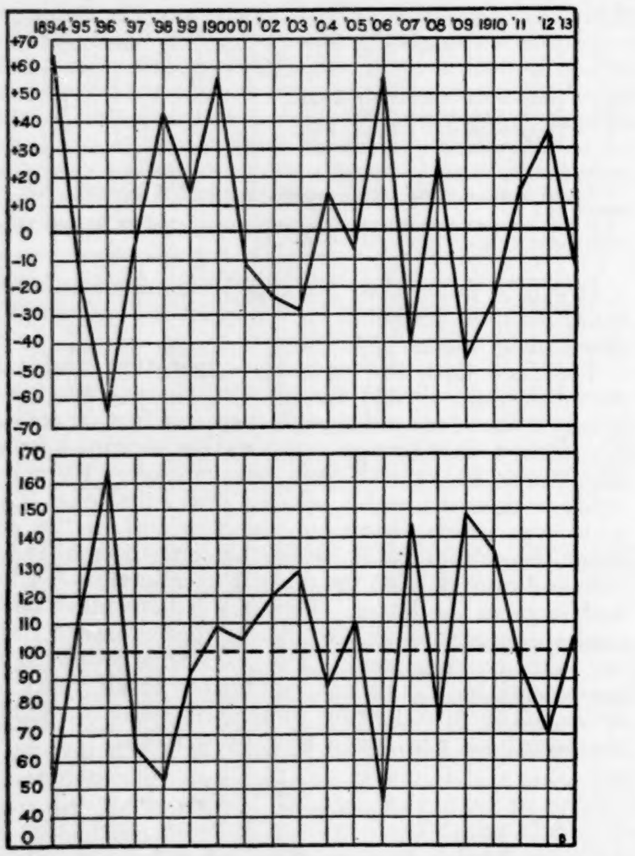
The fact that the normal temperature and rainfall would produce a yield much above the average has been briefly referred to, and this must receive further consideration before we can apply the values obtained from the departures of rainfall and temperature. By referring again to figures 1 and 2, we find in the first case that the yield was much above the average and in the second much below that value, while the departures of temperature and rainfall from the normal were small in the former and large in the latter. Obviously there must be intermediate departures that would produce values corresponding to the average yield. The value thus produced would necessarily be a constant, applicable to all years of the series. The introduction of this constant, d, completes the equation, which can now be written:

$$X=d-\frac{\Sigma(ac+bc_1)}{n}, \tag{4}$$

When $\frac{1}{n}\Sigma(ac+bc_1)<d$, X would be positive and when $\frac{1}{n}\Sigma(ac+bc_1)>d$, X would be negative. Moreover the magnitudes c and c_1 are so chosen that each unit of the final result obtained represents 1 pound of cotton per acre, thus making the computed values for rainfall and temperature departures comparable with the departure from the average yield.

TABLE 3.—*Departure of rainfall and temperature from the normal in Texas, 1894–1913.*

Months.	1894		1895		1896		1897		1898		1899		1900	
	Rainfall departure.	Temperature departure.	Rainfall departure.	Temperature departure.	Rainfall departure.	Temperature departure.	Rainfall departure.	Temperature departure.	Rainfall departure.	Temperature departure.	Rainfall departure.	Temperature departure.	Rainfall departure.	Temperature departure.
	Inch.	*°F.*	*Inch.*	*°F.*	*Inch.*	*°F.*	*Inch.*	*°F.*	*Inch.*	*°F.*	*Inch.*	*°F.*	*Inch.*	*°F.*
Apr...	+0.5	+3.2	−1.3	−0.4	−1.1	+1.0	−1.0	−1.6	−0.5	−3.0	−0.1	−2.7	+3.3	−2.5
May...	−0.1	+1.0	+2.4	−2.0	−2.2	+4.4	+0.4	−0.9	−0.8	+0.8	−1.0	+2.8	+1.3	−1.2
June...	−1.0	−1.3	+1.9	−0.7	−2.5	+3.4	−0.5	+0.5	+1.9	0	+3.2	−1.1	−1.5	+1.9
July...	−0.8	−1.3	0	−0.4	−0.4	+0.2	−1.8	+1.6	−0.8	−1.2	−0.3	−0.6	+2.6	−1.5
Aug...	+2.4	−2.6	−0.6	+1.3	−1.5	+2.7	−0.3	+0.3	−0.1	+0.5	−2.0	+3.1	+0.8	−0.8
Sept...	−0.1	+0.6	−1.1	+2.8	+1.8	+0.8	−0.6	−0.4	−1.1	+1.1	−1.2	−0.3	+2.5	+3.3
	1901		1902		1903		1904		1905		1906		1907	
Apr...	−1.0	−3.3	−0.9	+1.9	−2.0	−1.8	−1.0	−1.1	+3.3	−2.0	−0.3	−0.3	−0.6	−2.9
May...	−0.1	−0.8	+0.4	+2.5	−1.2	−3.3	+1.1	−1.4	+1.3	+1.5	−0.5	−0.2	+3.2	−5.4
June...	−2.2	+1.1	−1.5	+2.6	+0.6	−4.2	+0.8	−1.2	+1.1	+0.4	−0.8	+0.7	−1.8	−0.4
July...	−0.5	+1.3	+2.8	−1.0	+2.8	−1.9	−0.3	−1.5	+1.1	−2.0	+1.7	−2.0	−0.2	−0.6
Aug...	−2.2	+2.4	−2.5	+3.1	−0.6	−0.5	−0.6	−1.2	−1.6	+1.2	+0.7	−1.8	−1.0	+1.5
Sept...	+0.6	0	+2.2	−1.3	−0.3	−0.4	+1.2	+1.4	−0.5	+2.0	+0.7	+0.2	−1.1	+2.3
	1908		1909		1910		1911		1912		1913			
Apr...	+3.1	+0.5	−1.4	−0.7	−0.4	−0.7	+1.9	0	−0.1	−0.6	−1.0	−1.6	.....	.....
May...	+2.2	+0.2	−0.4	−1.1	+0.4	−0.9	−1.4	+0.1	−1.2	+1.4	−0.9	+0.4	.....	.....
June...	−1.0	+1.2	−0.1	+1.2	−1.6	+0.4	−2.6	+3.6	+0.1	−2.7	+0.1	−2.1	.....	.....
July...	−0.1	−1.5	−0.6	+2.6	−1.6	+2.3	+0.7	0	−1.8	+1.7	−1.7	+1.2	.....	.....
Aug...	+0.2	−0.8	−0.6	+2.0	−1.6	+2.8	−0.7	+1.6	−0.3	+1.2	−1.5	+1.4	.....	.....
Sept...	+0.5	−0.8	−1.8	+1.1	−1.0	+3.5	−1.2	+5.1	−1.3	+0.8	+3.8	−3.5	.....	.....



IG. 8.—The upper curve shows for Texas the actual departures from the average yield of cotton for the respective years of the period 1894 to 1913, inclusive, expressed in pounds per acre.

The lower curve presents the computed values resulting from the application of equation (3) to the respective rainfall and temperature departures given in Table 3.

The constant d.—The monthly departures of rainfall and temperature for the period under consideration are given in Table 3. By applying equation (3) to the departures for each of the years considered, we obtain values of varying magnitude, and, if our correlation stands, we should have small totals corresponding to large yields and large totals to small yields. By charting these values in conjunction with each other; that is, the totals obtained by computation, with the departure of yield from the average, for the respective years, the connecting lines should show a similarity, but have opposite directions. Figure 8 represents the result of this correlation, the upper curve representing the departures of yield from the average, and the lower one the values for the respective years as obtained by computation. In general these curves show a similarity, as expected.

Now, if a line be drawn through the lower curve to correspond with that in the upper representing the average yield, we find that it has a value of exactly 100 points above the base; it is represented by the broken line in the lower curve. This gives us a value for the constant d, viz, 100, which means simply that a total value of 100 points computed from rainfall and temperature departures is necessary to represent the average yield of cotton. All values smaller than this constant would produce a yield above the average and those larger a yield less than the average.

Table 4, column 1, gives the actual departures of yield and column 2 the computed departures. These results are indicated graphically in figure 9, where the solid line represents the actual departures and the broken one the computed values.

We compute from these results a correlation coefficient of $+0.88$, and a probable error of ± 0.03.

As the final result is obtained from the separate monthly values, the condition at the close of any month could be readily computed and expressed in percentage of the average, thus indicating the outlook at that particular time.

TABLE 4.—*Comparison of actual with computed departures of crops from normal yield.*

Years.	Actual departures.	Computed departures.
	Lbs./Acre.	*Lbs./Acre.*
1894	+65	+46
1895	−19	−14
1896	−64	−64
1897	− 5	+34
1898	+42	+47
1899	+15	+ 8
1900	+56	− 9
1901	−11	− 6
1902	−22	−20
1903	−27	−29
1904	+13	+13
1905	− 6	−10
1906	+55	+54
1907	−40	−44
1908	+26	+24
1909	−45	−48
1910	−25	−36
1911	+16	+ 5
1912	+36	+30
1913	−14	− 6

By referring again to figure 9 it will be noted that for the year 1900 the actual yield was much above the average, while the indicated yield was slightly below that value. An examination of the records of rainfall for individual stations for that year discloses the fact that very abnormal conditions obtained. The monthly averages for the State were above the normals for all of the months, save one, of the entire season, and for several months they were much above that value. However, the large average departures for the State were more apparent than really representative. For example, in July we find eight stations with an average rainfall of more than 16 inches, while a like number had an average of less than 1.5 inches. Thus the excessive falls for more

or less limited areas elevated the State average much above a representative value, thereby giving large departures from the normal and correspondingly small computed yield.

To overcome the difficulties presented by such abnormal conditions, it is believed that in correlations of this character, especially for limited areas and for regions where the summer rainfall frequently occurs in excessive amounts, some method of considering for such excessive falls only that portion that is actually absorbed by the soil, so far as this can be ascertained, should be devised. While it may not be practicable to ascertain these proportions definitely, yet by actual measurement of the water content of the soil at frequent intervals, or by measuring this content before and after rainfalls of varying intensities when runoff occurs, the relation of intensity of fall to runoff could probably be approximately determined. Also, it probably would be feasible to actually measure the runoff for selected limited areas where drainage is effected at a single point, by measuring

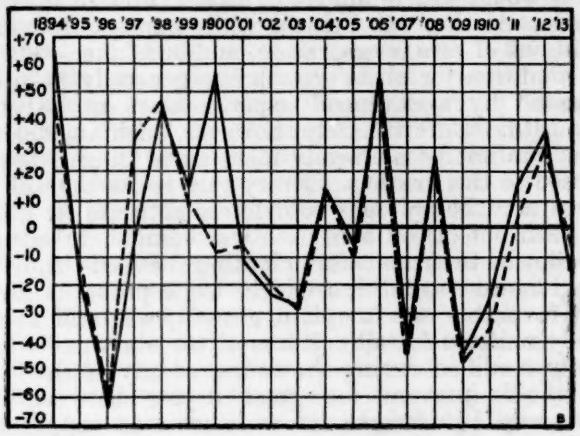


FIG. 9.—The solid line shows the actual departures of yield from the average, expressed in pounds per acre.
The broken line shows the values computed by the application of equation (4) to the departures given in Table 3.

the actual discharge at that point and reducing this to a uniform equivalent of water depth over the entire area. Again, an approximate relation might be established by careful, direct, or personal observations of soil condition and approximate runoff for falls of varying intensities, and the knowledge thus acquired could be utilized to advantage in compiling precipitation data for correlating purposes, as most original records indicate the time of beginning and ending of each rain and the total fall recorded. While only the approximate relation between intensity and runoff could be obtained by this last method, unquestionably it would afford better values of rainfall for correlating purposes than are obtained by accepting the recorded totals, irrespective of whether the entire amount was retained by the soil and utilized in the development of the plants, or a large proportion lost by runoff.

RELATION OF CLIMATE TO PLANT GROWTH IN MARYLAND.

By FORMAN T. MCLEAN.

[Dated: Johns Hopkins University, Baltimore, Md., Mar. 17, 1915.]

INTRODUCTION.

More and more attention is being paid to the relation between climatic conditions and plant growth by students of agriculture, forestry, and climatology. Progress in plant physiology and in agriculture, ecology, and forestry has made it quite clear that the growth of plants is definitely related to the nature of the environmental conditions. This principle has been most successfully applied to studies bearing on irrigation, cultivation, the use of fertilizers, etc. Regarding the relations between the plant and its environment above the soil, however, very little has yet been accomplished. These surroundings of the plant above the soil are the conditions usually termed climatic, and they have been very thoroughly studied by climatologists, but climatological study has seldom had plant relations as its main aim. Similarly, comparative studies of plant phenomena, such as growth, respiration, photosynthesis, and seed production, have not usually been carried out with the idea of relating them directly to climate. It is thus not at all surprising that the data of climatology and those of plant ecology have not been very satisfactorily correlated.

It therefore appears desirable to attack this problem of the climatic relations of plants by methods which are especially planned to bring out, as far as may be, possible correlations between the plant processes on the one hand and climatic conditions on the other. The work here to be considered is a preliminary and rather tentative attempt in this direction. It was carried on under the auspices of the Maryland State Weather Service, to the director of which, Prof. William Bullock Clark, the general project owes its beginning. The work was under the immediate direction of Prof. Burton E. Livingston, to whom the writer most gratefully acknowledges his indebtedness for his suggestions and assistance both in planning the study and in presenting the results. The author also expresses his thanks to Dr. Oliver L. Fassig, of the United States Weather Bureau, for valued assistance in presenting and interpreting the weather data; and his most sincere appreciation to the eight cooperative weather observers, who not only very kindly permitted us to use their private grounds for the experiment plots, but also kept special records in addition to the regular weather observations. We mention with deepest regret the loss of one of the observers, Mr. J. S. Harris, of Coleman, Md. The other observers who assisted in this study are Prof. A. F. Galbreath, Darlington, Md; Mr. J. H. Lawson, Monrovia, Md.; Mr. D. P. Oswald, Chewsville, Md.; President H. J. Patterson, College Park, Md.; Mr. H. Shreve, Easton, Md.; Mr. J. R. Stewart, Princess Anne, Md.; and Mr. R. E. Weber, Oakland, Md.

The previous work of the Maryland State Weather Service exemplifies the statement made above that ecological and climatic studies have usually been made quite independently of one another. "The Climate and Weather of Baltimore," by Oliver L. Fassig, and the "Climatology of Maryland," by Mr. F. J. Walz, represent very complete studies of the climate of the State, and Dr. Forrest Shreve's "Plant Life of Maryland" represents a corresponding study of the distribution of types of vegetation. The fact that Maryland has received such thorough and careful attention from these two points of view makes it a particularly suitable area for comparative work on the problem before us.

The study here reported was begun in the summer of 1914, and the work of the first season was devoted largely to perfecting and testing methods, so that this paper will deal primarily with methods of investigation and of interpreting results.

It was planned to bring out three sorts of relations between plant growth and environment: (1) The effect of local influences of climatic conditions due to differences in topography, altitude, soil, and exposure; (2) the effects

of seasonal influences, as between spring, midsummer, and autumn; and (3) the effects of other influences which are nonperiodic in character and unrelated to either location or season. For the comparison of plant growth and climatic conditions in different parts of the region nine cooperative Weather Bureau stations were selected, four near the shores of Chesapeake Bay and five inland, distributed from the coastal plain to the Allegheny plateau.

METHODS.

It was planned to carry the experiment through the entire frostless season, in order to ascertain the march of plant growth and of climatic conditions throughout one period of active plant growth. The last occurrence of killing frost in spring is about April 15 along the shores of Chesapeake Bay, while at the summit of the Alleghenies it is about May 15.[1] There were, however, delays in securing and installing the necessary equipment, so that the first experimental plantings at the nine stations here employed were not made until the first week in May. Thus no plant records were secured for the first three weeks of the frostless season at the coast stations, but at the other stations the season begins about May 1 or later, so that the first plantings were quite early enough to precede the beginning of the normal frostless season at these latter stations. The observations were continued until the occurrence of killing frost in autumn, at each station.

In order to compare the growth of plants to climatic conditions in different localities, it is necessary that the plants studied in each place shall be similar, both in their hereditary tendencies and in their general physiological condition at the beginning of the experiment. Therefore it is not possible to use the general rate of growth of field crops, in any two localities for any given time period, as an indication of the relations existing between plant growth and the climatic conditions at these stations. The seed from which the field crops were started would probably be of different strains, quite unlike in their response to external conditions and, even if the seed used were the same in both places, the plants would almost surely be different, due to differences in nonclimatic factors of the environment. Furthermore, it is practically impossible to find soils in two widely separated localities which are alike, either in physical character or in fertility. For these and other reasons, pot cultures were used in this study.

Plants of selected strains of wheat, maize, soy bean, and Windsor bean (*Vicia faba*, L.) were employed. The plants were grown in 6-inch pots. One pot culture of each species was started in each locality, approximately every two weeks, and each culture was continued for four weeks. Thus the culture periods overlapped, so there was always left a corresponding culture but two weeks old at the time each culture four weeks old was harvested. The average growth of all of the plants in a culture was used in each case, as a measure of the growth rate; this tended to overcome errors which otherwise might have arisen from individual variations of the plants.

The soil used was the same in all cultures, being of the type classified as Norfolk sand by Bonsteel.[2] It was all obtained from a single locality, near the railway station at College Park, Md. It is a moderately fine sand, with a water-retaining power of 43 per cent, by the Hilgard test.[3] The top soil was removed from a small area to a depth of 6 inches and was thoroughly mixed and sifted. It was placed in sacks and shipped to the different stations, where it was stored in air-dry condition, in covered water-tight cans, until used. Special precautions were taken so that the soils would be as nearly alike as possible, in both texture and condition, at the beginning of all cultures. By keeping it dry and isolating it from the surrounding soil it was, in a measure, prevented from becoming greatly modified by any chemical or biological agencies peculiar to the different locailties. The cultures were each of too short duration to admit of very great modification of the soil during the duration of any single culture, due to such special local influences.

Having thus provided soil of approximately uniform properties for use in the different localities, the next important step was to put it into the same physical condition in all cultures, and to have it all in such condition that it would well retain its structure through the course of a test lasting one month, while exposed to varying conditions of rain, evaporation, and sunshine. The best soil condition for plant growth has generally been demonstrated by agricultural experimenters to be one of loose tilth. Unfortunately, however, such an ideal condition can not be uniformly maintained in soils that are exposed to the weather. Every rain packs the soil more or less, and heavy ones completely saturate it. Therefore each pot of soil here used was completely saturated and allowed to settle before planting the seeds, thus being brought into a condition which, while probably not the most favorable one for plant growth, was still approximately uniform for all cultures at the start and was not greatly modified during the course of any of the experiments. To prevent too great drying between rains, porous-cup auto-irrigators[4] were used to supply moisture to the pots. As here employed, the instrument consisted of two porous clay cups (of the common form furnished by the "Plant World") joined to each other and to the water reservoir by glass tubes. The cups were vertical in the 6-inch pots so that their tops were level with the soil surface and were so arranged as to supply water to the soil under a pressure of less than an atmosphere. The difference between the pressure upon the water in the cup and that in the soil was overcome by the capillary attraction of the water films in the soil. In all the experiments of the past season the reservoir stood at a lower level than the pots, so that when it was full the water level was 14 inches below the soil surface.

By this arrangement the soil moisture in the pots was maintained at a minimum of approximately from 10 to 13 per cent, calculated on the basis of the dry weight of the soil, a condition rather too moist than too dry for the best growth of the plants. The soil of the cultures often showed a moisture content immediately after rains as high as 23 per cent, which was the approximate maximum water-retaining power of the 6-inch columns of soil in the pots, but it never was allowed to become very dry between rains.

The pots were plunged to such a depth that their soil surface was level with the surrounding soil, in order that the soil temperature in the cultures should approximate

[1] A very full discussion of the length of the frostless season in Maryland is given in **Fassig, Oliver L.**, The period of safe plant growth in Maryland and Delaware. Mo. WEATHER REV., 1914, **42**: 152-158.

[2] **Bonsteel, Jay A.**, The soils of Prince George's County. Baltimore, 1911. (Maryland Geological Survey publ.).

[3] **Hilgard, E. W.**, Soils, their formation, properties, and composition. New York, 1911. p. 209.

[4] **Livingston, B. E.**, A method for controlling plant moisture. Plant world, 1906, **11**: 39-40.

Hawkins, Lon A., The porous clay cup for the automatic watering of plants. Plant world, 1910, **13**: 220-227.

Transeau, E. N., Apparatus for studying comparative transpiration. Bot. gaz., 1911, **52**: 54-60.

that of the soil around them. The culture soil was isolated from the surrounding soil by waterproofing the pots on the outside, but this coating became leaky before the end of the month. The entrance of soil water from without and of dissolved salts, could not have been great in any case, however, for the soil inside the pots was always much moister than the surrounding soil; thus any water movement through the walls of the pots should have been outward rather than in the opposite direction. These matters of soil and soil moisture require somewhat detailed attention, for these two factors appear very frequently to be the most influential ones in determining plant growth in this region. They must be at least partially controlled before the effects of other factors upon culture plants may be studied with any hope of satisfactory results. Of course it is to be remembered that in controlling soil moisture one of the direct effects of the factors of rainfall and evaporation was modified.

Four climatic factors were here considered—rainfall, evaporation, temperature, and sunshine. The records of temperature and rainfall were obtained from the observations of the cooperative Weather Bureau observers, the cultures being located close to the stations. The average air temperature during each experiment was computed by the formula ½ (max. + min.), the self-recording thermometers being read daily at sunset. The rainfall measurements were summed for the experimental periods.

The sunshine data were obtained from the instrumental record of the nearest regular Weather Bureau station. Those of Washington, D. C., and Baltimore, Md., were combined and the average of the sunshine of these two stations was used to represent the general condition in the region around Easton, Md., and the records of Elkins, W. Va., were similarly used to represent the sunshine in the Oakland region. These were used in preference to the local observers' estimates of clear and cloudy days, because they are much more detailed and less affected by differences in individual judgment. The great similarity between the two kinds of records for the same general area seems to justify this application of the instrumental records of sunshine at a few stations to an extended region. These instrumental records are only approximations of the effectiveness of sunshine in promoting plant growth, as the Marvin instrument (Marvin sunshine recorder) begins to record sunshine when the intensity is above a certain arbitrary minimum, and records no sunshine when the intensity is below this. The instrument thus takes no account of the absolute intensity of the total solar radiation or of the relative intensities of the different wave-lengths of light, both of which are important in their effects upon plant processes. The records of sunshine used, however, are the best that are available at present. The number of hours of sunshine is used as a basis for comparison in preference to the percentage of possible sunshine, because the number of hours of possible sunshine, upon the basis on which the latter is computed, is a variable quantity. Thus a certain percentage of possible sunshine in June indicates a much longer duration of sunlight than does the same percentage in April or November, for instance.

In these experiments a rain could operate as a disturbing influence only by increasing an already abundant supply of moisture. Of equal importance with the water supply of plants is the water loss from them. Most of the water loss of plants occurs by evaporation, and its rate depends in part upon surrounding atmospheric conditions. This evaporation was here measured by means of standardized cylindrical porous cup atmometers of Livingston's type furnished by the Plant World. Atmometer readings were obtained at every visit to the stations, about once each fortnight in each case, and all readings were reduced to standard values for comparison, by correction to Livingston's standard cylindrical atmometer.[5]

EXPERIMENTS AND RESULTS.

The results of this study are not yet all computed, but the methods of procedure and the kind of results secured can be best set forth by concrete examples for a single plant form and for the two stations having the greatest differences in climatic conditions. The relation between the dry-weight production of soy bean plants grown one month from seed, and the observed weather conditions. at Easton and at Oakland will alone be presented here These two stations are in extreme locations. The Easton station on the eastern shore of Chesapeake Bay, the low flat coastal plain, has a mild, equable climate, with a small daily range of temperature. The Oakland station, on the other hand, upon the gently rolling tableland at the summit of the Allegheny Mountains, 2,500 feet above sea level, is on a moderate south slope near the bottom of a shallow stream bed. It has a more rigorous climate than Easton, with a rather large daily range of temperature.

A comparison of growth rates of a single species during a single season does not, of course, furnish a sufficient basis for a general comparison of local differences in climate between two localities, and this phase of the problem can not as yet be discussed. The present paper will therefore deal mainly with comparisons of the seasonal differences in growth of soy bean plants at the two stations, and of the climatic conditions under which these differences developed.

The production of dry matter (solids) in soy bean stems and leaves is used here as a measure of growth, as it appears most nearly to sum the results of all the processes of plant nutrition. Growth in height, leaf area, green weight, etc., are at least partly dependent on the amount of swelling due to imbibed water and resulting turgor conditions in the plant tissues, but water is surely not as important a component in the final yield of the plant as is the amount of dry material accumulated. This latter is quite accurately gaged by measuring the resulting dry weight.

The results of these measurements, expressed in graphic form, are shown in figures 1 and 2. The ordinates of the graphs are values of the different weather and plant data, and the abscissæ represent time and season, being the dates of harvest of successive cultures. Thus each graph shows the successive values of a single index as it varies through the season. All of the data of a single station are assembled in one set of graphs, those of figure 1 referring to Oakland, where 8 cultures were harvested, and those of figure 2 to Easton, where 12 cultures were harvested. All values have been reduced to a day basis. The age of each culture when harvested was approximately four weeks, but the growth periods of the successive cultures overlap so that one was harvested about every two weeks. The average daily growth rates of the different cultures, in milligrams of resulting dry weight, are shown by the lowest graph as points whose abscissæ are the dates of harvest. A horizontal line extending to the left of each point represents the length of the growth period for each culture. All the remaining data are computed as aver-

[5] Livingston, B. E., A rotating table for standardizing porous-cup atmometers, Plant world, 1912, 15: 157-162.
Atmometry and the porous cup atmometer, Plant world, 1915, 18: 21-30.
Atmospheric influence upon evaporation and its direct measurement, to appear in MONTHLY WEATHER REVIEW, March, 1915.

ages for periods corresponding to the culture periods. Rainfall is expressed in terms of depth in fractions of a centimeter per day; soil moisture is expressed as a percentage of the dry weight of the soil; evaporation is expressed as cubic centimeters of loss from Livingston's standard atmometer; sunshine is expressed as the number of hours of sunshine per day; and temperature is expressed as the average daily mean temperature [½(max. + min.)] in Fahrenheit degrees. Each climatic factor is thus

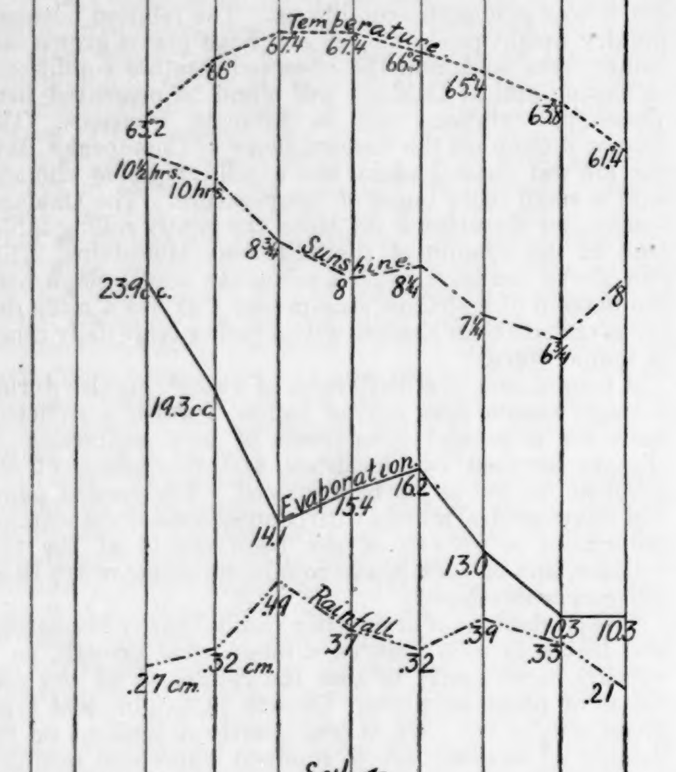


FIG. 1.—Environmental conditions and growth in dry weight of soy bean, Oakland, Md., 1914. Temperatures F.; evaporation from Livingston's atmometer in cubic centimeters.

measured in its own kind of unit. It is obviously impossible to express these incommensurable magnitudes in the same unit or in units that are in any way related. By expressing all the magnitudes of each single graph in terms of the actual magnitude shown for some given period, the same period being thus used as a basis for the reduction of all graphs, the slopes of the graphs might be rendered comparable, but this mode of treatment has not appeared requisite here, except in two cases which will receive attention below. Comparisons between these graphs are to be made only with respect to the times of occurrence of maxima and minima, and with respect to the relative directions of their slopes, whether upward or downward.

The averages here employed do not, of course, bring out the extreme fluctuations in conditions which were recorded. While it is possible, and indeed very probable, that the extremes of conditions within the growing season may frequently affect the plants in a marked manner, yet the method of arithmetical averaging here used is the simplest and most direct form of treatment, and it seems best adapted to a preliminary study such as this. More

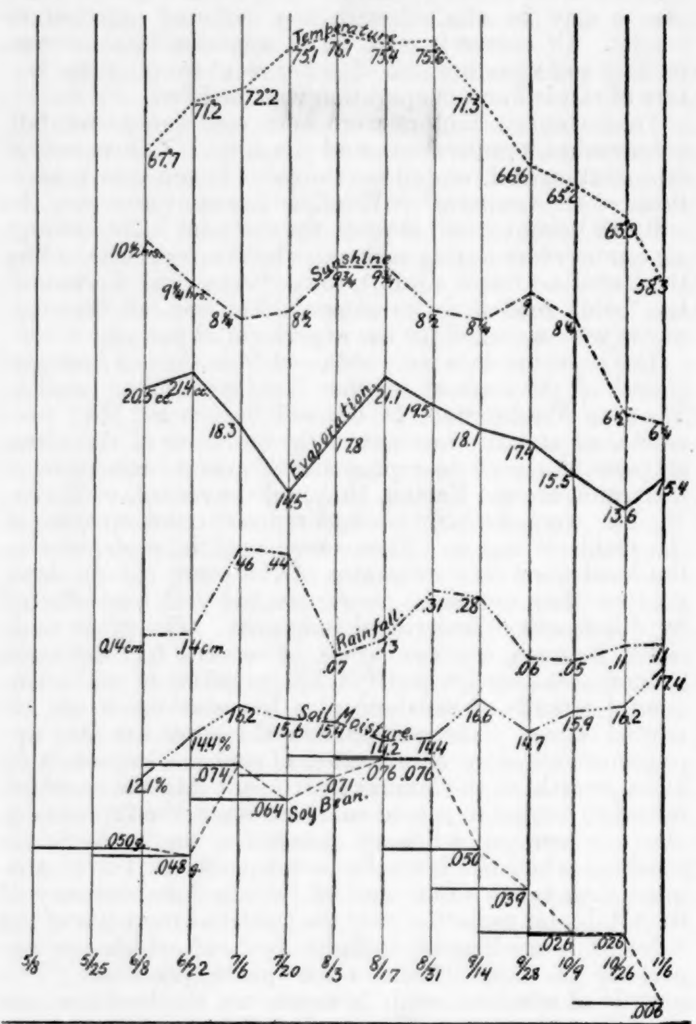


FIG. 2.—Environmental conditions and growth in dry weight of soy bean, Easton, Md., 1914. Temperatures F.; evaporation from Livingston's atmometer in cubic centimeters.

refined treatment of the data, taking account of the interdiurnal and diurnal variations of temperature, etc., is not yet justified.

The most evident features of both series of graphs in figures 1 and 2 are the increasing growth rate of the plants in the spring and the decreasing rate in the autumn. For Oakland the growth rate follows an almost uniform seasonal curve, rising to a crest between the middle of June and the middle of July. For Easton the seasonal relation is less regular, there being a depression of the rate in early July while the crest is reached in August, but the same general relation to season is evident for both stations.

Each point on these two graphs of dry-weight increment represents a distinct culture and a separate lot of plants. Each culture consisted of from three to six plants, with an average number of five. These are all weighed in bulk, so that variations in the dry weight of different individuals of a culture can not be ascertained. Various other measurements of growth showed, however, a general agreement with those of dry weight, and from the former measurements it is possible to get an idea of the range of individual variation between the plants in a single culture. For example, the average leaf length in each individual plant at the age of two weeks exhibited a mean deviation from the average, among individuals of the same culture, ± 11 per cent. Since there appears to be a close relation between the two plant dimensions, average leaf length and total dry weight of stems and leaves, it is perhaps safe to suppose that the individual variations in dry weight within the same culture may have been of about the above magnitude.

Whether this assumption is really justified or not, the individual variations are so small are so small that it seems improbable the averages for the cultures might be very markedly affected by them. It seems safe, therefore, to consider the marked seasonal variations in growth, as indicated by the dry weights per culture, were related to climatic conditions rather than to unknown conditions bringing about individual variations among the plants. These seasonal variations in growth of soy bean plants show a range from 0.024 to 0.059 gram for the Oakland station and from 0.006 to 0.076 gram for Easton.

Considering the latitude of Maryland, which lies between 38° and 39° 45′ N., and its humid, coastal climate with the rainfall normally distributed rather evenly throughout the year,[6] the sunlight intensity and temperature should suffer the most important seasonal changes. The summer of 1914 was rather dry, but this fact does not appear to have influenced the dry weight production here considered. The graphs of rainfall, soil moisture, and evaporation show no apparent direct relation to the seasonal changes in the growth rate. The main effect of rain upon plant growth, as this would occur in the field (that is, the influence of increased soil moisture at times of rain and that of drought during longer periods without rain) was not met with in these auto-irrigated cultures. As would be expected, therefore, the graphs show no apparent relation between the seasonal variations in growth rate and the observed variations in either soil moisture or precipitation.

Neither does the graph of evaporation exhibit any observable parallelism to the graph of dry weight; apparently the plants were so well supplied with water at their roots that the comparatively slight variations in this condition as here shown, were without sensible effect upon the rate of production of dry substance. Likewise, there is no discoverable relation between the number of hours of sunshine and the dry weight. It is to be noted that the sunshine graphs in figures 1 and 2 do not show any seasonal trend.

Temperature.—The remaining climatic influence here to be considered is temperature, which is quite different from the others just mentioned in that there appears to be an unmistakable relation between its intensity and the recorded growth rates at both stations. For Oakland this relation is very evident (see fig. 1); the maxima of both graphs coincide, as do also their minima, and the general direction of slope is the same for both graphs. The only very apparent discrepancy between these two graphs occurs in the case of the culture harvested on July 30 (column 7/30 in fig. 1), when the average daily mean temperature was the same as in the preceding culture, but the growth rate fell from 0.59 gram to 0.048 gram, a decrease of 19 per cent. This decrease is perhaps to be attributed to some unknown influence, perhaps to some other climatic condition, or to a less equable variation of temperature in the latter case.

For Easton (fig. 2) the relation between mean daily temperature and soy bean growth is less consistent in some respects, but there is the same general agreement here as at Oakland. The highest growth rate occurs with high temperatures, from the middle of July (7/20 in fig. 2) to the last of August (8/31 in fig. 2), and the descent from this to the end of the season is quite regular for both mean temperature and growth rate. In the early part of the season there are three apparent discrepancies. The temperature rises from the first to the second period (6/8–6/22), while the growth rate falls. Also, in periods 4 and 5 (7/20 and 8/3), at the highest temperatures the growth rate falls off. Thus, while there is a general agreement between the average daily mean temperatures and the growth rates, these two groups of data disagree somewhat in four of the twenty cultures grown at the two stations. The information at hand is not sufficient to attempt an explanation of these discrepancies at present.

The plotted graphs in figures 1 and 2 assist in comparing the general trend of the different elements as they vary through the season, but they do not permit us to compare the slope values because they are necessarily plotted on different scales and the units are not commensurable. To make them comparable, they may be reduced to terms of a common unit by stating them in percentages of the values of some single period taken as a basis. For this purpose the temperature and the dry weight for period 6 (8/31 of fig. 2) at Easton are taken as the respective unities, as this period shows the highest growth rate at Easton. It is clear at once that the zero of the growth rate does not at all correspond to the zero temperatures of the Fahrenheit thermometer scale, and therefore one or both of the two series of data must be so modified as to make the two starting points as nearly simultaneous as possible. Various investigations have shown that growth ceases in many plants when air temperatures are between 40° and 43°F. Therefore, 40°F. may be tentatively considered as the point on the Fahrenheit thermometer scale corresponding to the zero of plant growth. By subtracting 40 from each daily mean temperature as given in figures 1 and 2, the respective remainders may be taken as the "effective temperatures"[7] as far as growth is concerned. This simple subtraction seems to be here permissible, since the daily mean temperatures during the season here dealt with were never below 40°F. This method is somewhat similar to that frequently employed by phenologists, of summing the daily mean temperatures above a certain temperature value, and comparing this to the time required to complete a given growth process. Here, however, rates per day are used, while the phenologists have employed summations for the entire period of observation. Though the writer knows of no experiments upon the relation of temperature to the growth of soy bean plants it appears best to employ the temperature value 40°F. as the zero point here required. The growth of the plants and the corresponding temperatures are computed on the above basis and set forth on the graphs

[6] See B. C. Wallis in this REVIEW, January, 1915, 43: 11-23. — C. A. Jr.

[7] This term "effective temperatures" is here used in a sense widely divergent from that recorded in Abbe—"Relation between climate and crops, 1905. (W. B. bull. 36) p. 170.

of figure 3, which are arranged similarly to those of figures 1 and 2.

As was evident in figures 1 and 2, the graphs of effective temperature and dry weight production show the same general trend, this similarity being more marked at Oakland than at Easton. The lowest growth rates occur in the early and late parts of the season, with the lowest temperatures, and the highest growth rates are recorded for the intervening period of higher temperatures. Another point not shown at all in figures 1 and 2 is here clearly brought out: While the temperature graphs for Oakland and for Easton are roughly parallel each section of the former lies entirely below the corresponding section of the latter, which means simply that the "effective temperature" index for the Oakland station was always lower than the corresponding index for Easton. This difference is by no means constant,

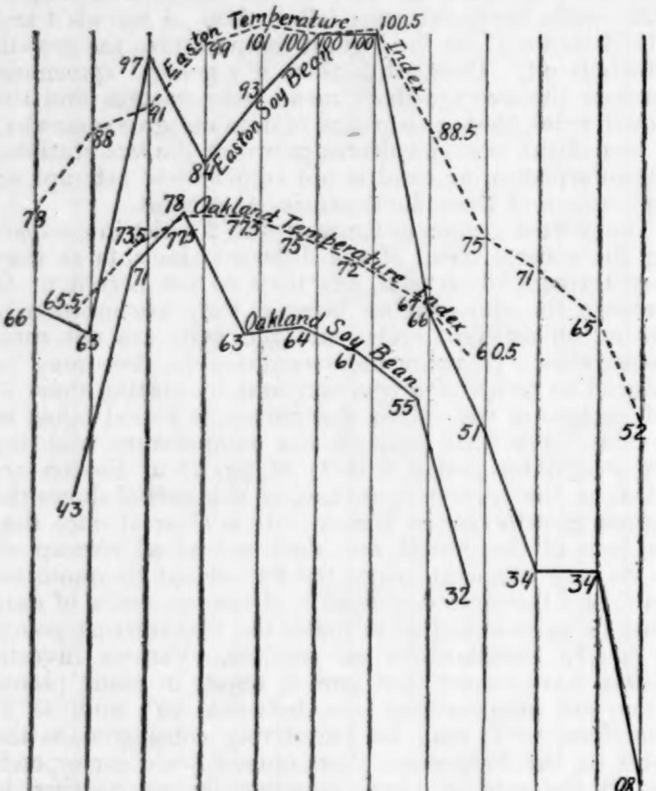


FIG. 3.—"Temperature indices" and growth of soy bean, Easton, Md., and Oakland, Md., 1914.

but has a value of approximately 20 throughout the period common to the two temperature graphs, i. e., following the notation here employed, the temperature efficiency for plant growth at Oakland was, throughout the eight Oakland periods, about 20 per cent (of its value at Easton for the sixth Easton period) less than it was at Easton throughout the corresponding eight periods. For these eight common periods the temperature graph for Easton exhibits values increasing from 88 to 100.5 and then decreasing to 75, while the corresponding march for Oakland is from 65.5 to 75.5 and then to 60.5. It is to be remembered that these magnitudes are all obtained by assuming "temperature efficiency" for growth to be proportional to the temperature above 40°F. and by considering the sixth period at Easton to be 100.

In this connection it is to be noted that the season of observation began one period later and ended three periods earlier at Oakland than at Easton. The early cessation of observations at Oakland was caused by the occurrence of killing frosts at that station. The three additional periods at Easton show a continued decrease in temperature efficiency as here calculated, and the last "index" has a value of only 52, which is 8.5 lower than the last "index" recorded for Oakland. This point illustrates an apparently important feature of the seasonal climatology of these two stations. The station with the shorter frostless season is deficient in total "temperature efficiency," not only on account of generally lower indices but also on account of the premature end of its season while the "index" values are still comparatively high. This does not appear to have been thus emphasized before.

While the general trend and slope direction of the graphs is, on the whole, much the same for the temperature and growth in both cases, as has been noted, yet it is clear from figure 3 that the two graphs are not parallel in the case of either station. In both pairs of graphs the one for dry weight increases in general more rapidly to its maximum region than does that for "temperature efficiency," and it also falls more rapidly after the maximum region is passed. For both stations the growth graph passes somewhat above that for temperature, thus intersecting it at two points. For Easton the two graphs coincide for the sixth observation period, being arbitrarily so arranged, as above stated. An unexplained feature occurs for the fourth and fifth periods of the Easton series, in that the graph of dry weight exhibits an apparently inconsistent concavity upwards in this region. By referring to figure 1, and comparing the graphs of evaporation and of dry weight production of soy bean plants, it appears that this concavity upwards of the graph of the growth rate in periods 4 and 5 corresponds to a similar concavity upward in the graph of evaporation into the air. While this coincidence at least suggests a possible explanation of the behavior of the growth rates in these two periods, the data here presented are not sufficient for a critical discussion of the probabilities. For the present discussion, therefore, this concavity upward will not be further considered.

The general lack of parallelism between the two graphs of each pair (that is, the difference between the slope values or rates or rise and fall) in figure 3 seem to indicate that the higher temperatures were relatively more efficient in producing dry weight material in these plants than were the lower ones. Thus, for Easton, a "temperature index" of 88.5 (eighth period) corresponds to a relative dry weight of 66 (the ratio of these numbers being about 0.75), while a "temperature index" of 100 (sixth period) corresponds to a "dry-weight index" of 100 (the ratio of these being arbitrarily fixed at unity). This difference between the relative efficiencies, in general, of the higher and lower temperatures appear to be a very real feature of these results, one which is well worthy of further quantitative study. Just what conditions may control it is at present impossible to decide, but it may here be suggested that this peculiar relation between the two graphs as here presented may possibly be related to one or more of three different considerations: (1) The assumed minimum temperature for the growth of the plants (40°F.) may be too low for soy bean. This seems somewhat probable, since the indicated growth is so very low with the moderately high temperature of 58.3°F. (Easton, twelfth period). (2) The method here employed for deriving "temperature efficiency" from the mean Fahrenheit temperatures (subtracting a certain number from each of the latter) may not be at all appropriate for

other than rough approximations within a narrow range of temperature. This is rendered probable by the studies that have been reported on the "temperature coefficients" of plant growth.[8] (3) Some other environmental factor, besides temperature, may be influential here; if such be the case it appears to be some factor rather closely related to temperatures in its seasonal march, being more effective with high temperatures than with low ones. Such a possible factor is perhaps sunshine intensity, for which, as has been noted, adequate measurements were not available in the present study.

CONCLUSIONS.

While the studies briefly reported above are to be regarded as simply of a preliminary nature, several valuable points seem to have been brought out. In the first place, tests have been made of several new methods of approach to the general problem of relations between plant growth and environmental conditions and these are here recorded. In the second place, some quite tentative but nevertheless apparently important results have been obtained concerning the temperature and other climatic relations between the two particular stations here dealt with.

Perhaps the most important advance in methods here considered is that which involves the employment of like seeds grown in small pots of like soils, for approximately equal and coincident short periods of observation at the different stations. This procedure amounts to the employment of the plant itself as an integrating instrument for (or an indicator of) the effectiveness of the environmental complex as this influences plant growth during such short periods. These plant indicators are, of course, used up in obtaining the summation for each short period, and new plants are started frequently (as though new instruments, *set at zero*, were thus installed) so as to give a continuous series of overlapping integrations. By employing the same soil at the different stations, the influence of soil is at once removed from comparative consideration. In these studies the effect of precipitation upon soil condition (water content mainly) was also removed from consideration by the employment of the auto-irrigator, which effectively prevented the soil masses of the culture pots from ever becoming very dry. Rains raised the soil moisture content considerably above the optimum for longer or shorter periods, but it was never allowed to fall markedly below its optimum. Livingston's cylindrical, porous-cup atmometer was here employed with apparently satisfactory results to secure a measure of evaporation into the atmosphere, as it may affect water loss from plants. The adequacy of daily temperature maxima and minima and daily average temperatures in this sort of work is clearly shown.

In the handling of the various kinds of data resulting from these series of measurements a method which is not new, but which seems not to have been generally employed in this sort of work, has been resorted to, and is illustrated in the foregoing treatment of the relation between temperature and growth. We have deduced average mean daily "temperature efficiencies," or "temperature indices," from the mean daily air temperatures (°F.) by subtracting 40° from the mean, on the rather common phenological supposition that plant growth begins only above 40°F., and that each degree of temperature above this point represents the same increment of "temperature efficiency" for growth. These "indices" were then reduced to terms of the particular "temperature index" that corresponds to the highest growth rate encountered in these two series of observations. Thus the "temperature efficiency" (mean daily temperature *minus* 40) for the sixth observation period at Easton was taken as unity and all other temperature efficiencies (for Oakland as well as Easton) were stated as hundredths of this assumed unit. A similar treatment of the growth rates, using the rate at Easton for the sixth period as unity, brought the growth rates and "temperature indices" throughout into a comparable series. This method allows the "intensity" or "index" of any environmental factor and the rate of any plant process, at any station and for any period, to be expressed in terms of the corresponding index or rate for any other station or period. Thus, for example (see fig. 3), the growth rate for the third period at Oakland is given as 0.78 of the assumed unit of growth rate and the temperature efficiency for the same period is given as 0.775 of a comparable unit, for each represents the degree of divergence of the respective values from the corresponding values at a stated time and place, which are taken as the standard of comparison. By making the units of different features correspond to the same observation period, the seasonal marches of the different features may be directly compared.

The present comparison between plant growth and climatic conditions at Oakland and at Easton, two climatically very different stations, has brought out several at least interesting results, which are to be considered as directly applicable only for the conditions and for the plant form (soy bean) here dealt with, for the summer of 1914. These are summarized below.

With plentiful soil moisture, in a light soil, a range of mean daily precipitation from 0.05 centimeter (0.02 inch) to 0.50 centimeter (0.20 inch), together with a low rate of evaporation (ranging from 10 to 24 cu. cm. per day from Livingston's standard cylindrical porous clay cup atmometer), were without noticeable influence upon the growth rate of soy bean plants in the first month of their developmental history. The growth of these plants was apparently controlled by other conditions than that of water.

Under the conditions here encountered soy bean exhibited a pronounced and somewhat regular march of its growth rate (as measured in terms of the dry-weight material accumulated in leaves and stems during the first month of its growth from seed) throughout the growing season. This rate increased to a maximum in the summer and then decreased. The maximum rate of production of dry matter occurred in the warmest part of the season, and the march of this rate is represented by a graph of about the same general form as that possessed by the corresponding graph of air "temperature efficiency" (considering 40°F. as the physiological zero of temperature for growth). Nevertheless, the slopes of these two graphs, while alike in general direction, proved not to be the same in magnitude; the "temperature efficiency" for the production of dry weight of these plants was shown to be relatively much more effective with high temperatures than with low. This feature suggests either that the method here employed for deducing "temperature efficiency" from temperatures on the Fahrenheit scale may not be feasible for the plant form and for the conditions here dealt with, or that some other condition added its effect to that produced by temperature in the warmer portion of the season. Under the conditions of these tests the growth rate tended to vary almost directly with the "temperature index" when the air temperatures were low. With high air temperatures the growth rate

[8] Lehenbauer, P. A., Growth of maize seedlings in relation to temperature. Physiol. researches, 1914, 1:247-288.

was relatively much greater than can be accounted for by the "temperature indices" alone. The agreement in this regard, between the data from the two very different stations included in these studies, seems to suggest that this feature may be general for a considerable range of conditions, at least for the plant form here considered.

With the given soil and soil moisture content the intensities of evaporation experienced by these soy bean plants were apparently not sufficiently high seriously to overtax the process of water absorption or that of water conduction. Had the possible rate of water supply to the roots been sufficiently diminished, had the rate of evaporation into the air been sufficiently increased, or had both of these alterations occurred together, then the water relation should have had a more pronounced influence upon the growth rate. It might, indeed, have obscured the effects of the temperature relation. As the experiments were carried out, however, the seasonal changes in temperature were apparently much more important in the control of growth than were the changes in any other measured condition or conditional complex.

A comparison of the seasonal march of the growth rate for Oakland with the corresponding march for Easton brings out three important considerations. (1) Neglecting an unexplained and temporary fall in the rate, shown for the fourth and fifth periods at Easton, the graphs representing these two seasonal marches have much the same general form, but the top of the Easton graph appears flat, while that for Oakland rises to a definite maximum, and then rapidly falls. (2) As is clearly depicted in figure 3, the growth rates of the Oakland series are markedly less than the corresponding ones of the Easton series, these quantities being rendered strictly comparable by stating all of them in terms of the growth rate for the sixth period at Easton considered as unity. In general, the Oakland rates are found to be from about 10 to about 20 per cent or more (on the basis of the assumed unit) lower than the corresponding rates for the other station. (3) The early occurrence of frost at Oakland brought the season to a close earlier than was the case at Easton, and the last growth rate for the latter station is shown as markedly lower than any encountered at Oakland. The principle here brought out is worthy of considerable emphasis. For a short frostless season, characterized by a great daily range of temperature, the lowest growth rate may be generally expected to be higher in value than the lowest rate for a longer frostless season, with more equable temperatures.

NEW ZEALAND RAINFALL IN 1914.

By Rev. D. C. BATES, Director.

[Dated: Dominion Meteorological Office, Wellington, New Zealand, Feb. 17, 1915.]

The year 1914 will long be remembered as one of the most trying ever experienced by the farmers and pastoralists of New Zealand. The winter months (June, July, and August), proved mild, and the rainfall, compared with the averages for previous years, was generally deficient. This dry season was followed by an exceptionally dry spring, but added to this was a summer in which greater quantities of rain were much needed. Though "absolute droughts," in a technical sense, were rare, and absolute minimum monthly rainfalls were not made in any long records of stations, such a continuation of dry conditions was distressing, and such a succession of dry seasons had not previously been regarded as possible in the Dominion. Month after month the total rainfalls were below the averages for the month in previous years in most parts of the Dominion, but it is remarkable that in Southland conditions were almost reversed, and heavy and frequent rains were there experienced during the year. In the South Island the monthly means for previous years show a fairly even distribution of rainfall throughout the whole year; but winter is the rainy season of the North Island. Such was not the experience in 1914, and the leading meteorological feature which accounts for it is the absence of ex-tropical disturbances of a cyclonic character and a counterbalancing prevalence of "brave" westerly winds which held sway during the greater part of the dry period.

Occasionally while Australia has a "dry time" New Zealand has abundant rainfalls, but both suffered in 1914, and it is noticeable that reports from England and France indicate that a somewhat similar and remarkable succession of months of deficient rainfall was experienced in other parts—in England and France at least. Other regions may also disclose irregularities in the precipitation of the world, and when these can be properly compared and studied it is possible that men may recognize reciprocal relationships and trace common cosmical causes which are as yet unknown.

Scattered over the globe are thousands of observers who carefully and patiently, and in the vast majority of cases voluntarily, record the rainfall of their neighborhoods. The cumulative results of their humble devotion to science must undoubtedly prove of great value to their own immediate localities and the countries they inhabit, but the fruits of their observations may, it is hoped, reach a much higher appreciation in the future when more is known of the laws governing precipitation. Rainfall, it may be remarked, is now the least certain element, although the most important item in weather forecasting.

The following table has been computed to show the percentages of rainfall compared with the monthly averages at select stations during the several months of the year in various parts of New Zealand.

TABLE 1.—*Monthly percentages of average monthly rainfalls at selected stations in New Zealand during 1914; number of months having falls above (+) and below (−) their respective averages; and the total annual falls for 1914.*

Place.	January.	February.	March.	April.	May.	Winter.			September.	October.	November.	December.	Months above or below average.		Total rainfall for year 1914.
						June.	July.	August.					+	−	Inches.
NORTH ISLAND.															
Auckland	51	56	77	124	106	71	81	28	40	32	44	61	2	10	28.42
Te Aroha	39	35	137	149	59	45	55	29	25	25	37	69	2	10	31.98
Rotorua	22	56	69	145	49	62	70	18	44	27	24	53	1	11	29.70
Tauranga	28	26	110	188	42	35	42	9	31	23	16	48	2	10	30.66
Gisborne	22	59	176	90	236	56	14	80	19	23	36	9	2	10	38.71
Greenmeadows, Napier	14	62	111	101	137	6	4	38	14	8	56	21	3	9	22.12
New Plymouth	80	75	43	128	74	33	50	28	29	46	120	122	3	9	39.79
Moumahaki, Waverley	53	133	23	131	154	81	66	45	45	64	80	94	3	9	38.38
Palmerston North	120	78	34	140	130	63	54	57	34	51	95	124	4	8	33.22
Taihape	65	145	65	86	136	63	81	30	33	34	58	71	2	10	31.71
Masterton	56	91	67	133	151	76	26	33	41	18	62	78	2	10	28.17
Wellington	79	56	68	64	166	76	43	25	36	37	59	60	1	11	31.90
SOUTH ISLAND.															
Hokitika	141	78	33	134	96	56	86	66	88	58	191	134	4	8	112.32
Nelson	36	112	54	171	110	75	91	18	9	17	*100	64	3	9	26.01
Christchurch	65	57	44	125	162	99	18	44	37	61	108	110	4	8	19.90
Lincoln	104	86	57	124	189	82	18	25	30	81	98	106	4	8	20.95
Timaru	149	159	107	90	125	28	13	54	8	33	113	65	5	7	17.99
Waimate	178	192	132	166	93	70	18	35	17	53	90	76	4	8	23.14
Dunedin	106	114	59	124	81	88	69	24	62	60	107	111	5	7	31.31
Gore	166	172	36	128	151	163	169	116	123	99	215	114	10	2	38.89
Invercargill	132	85	17	126	91	141	97	144	152	101	116	117	8	4	49.58

* Was a fraction below the mean.

GIGANTIC SNOWFLAKES.

About 4:30 p. m. on January 10, 1915, Berlin experienced a brief fall of snow during which snowflakes of very considerable dimensions occurred simultaneously with those of more usual size. On this occasion a large number of snowflakes had diameters of 8 to 10 centimeters, and these giant flakes fell with both a greater speed and more definite paths than did the smaller flakes. They did not have the complicated, fluttering flight of the latter. In form the great flakes resembled a round or oval dish with its edges bent upward. During flight they rocked to this side or that, but none were observed to turn quite over so that the concave side became directed downward. The temperature was but little above freezing.

Dr. Baschin refers in his report [1] to analogous occurrences observed in 1887. On January 7 of that year, at Chepston, England, very large flakes were observed by E. J. Lowe [2] from 12:12 p. m. to 12:20 p. m. At that time the temperature was +0.3°C. and the relative humidity 100 per cent. At first the flakes were 6½ centimeters, then 7 centimeters, and finally 9 centimeters in length; and even larger ones were observed to fall outside the cooled dish in which the observer was attempting to catch them. The weight of 10 flakes varied between 1.1 grams and 1.4 grams; in water content one flake yielded 14 drops, a second yielded 15 drops, and another 16 drops. A falling flake 9 centimeters long, 6.5 centimeters wide, and about 4 centimeters thick, was compressed to 0.6 centimeter thickness by its own impact upon the little glass dish that caught it. The snowflakes under consideration were not composed of fragments, but of hundreds of undamaged crystals set together at all angles in a manner which Lowe illustrated. He believed that he could observe the greater flakes exerting an attraction on the small ones; but in part he explained the increasing size of the big flakes by their rapid fall whereby they could overtake a large number of the small flakes. Mr. Lowe also reported that he had seen such large flakes but once before, viz, in January, 1838, when the flakes had attained a length of 5 centimeters (2½ inches).

In the same winter of 1887 very large snowflakes were reported [3] as having fallen on January 28, near Matt. Coleman's ranch at Fort Keogh, Mont. In this case, which is not recorded in the MONTHLY WEATHER REVIEW for that year, the great flakes were described as being "larger than milk pans" and measuring 38 centimeters (15 inches) across by 20 centimeters (8 inches) thick. A mail carrier who was caught in the storm verified the occurrence. These tremendous flakes made patches all over the fields within an area of several square miles.

On January 24, 1891, during one of the heaviest snowstorms known up to that time in Nashville, Tenn., very large snowflakes were observed there. "Many flakes were as large as a dollar (3.8 centimeters) and some nearly as large as a saucer (14 centimeters)." [4]

On March 25, 1900, Richmond, Va., also enjoyed the spectacle of falling snowflakes of very large size.[5] On the morning of that date Richmond had cloudy weather with a fresh, chilling wind from the northeast. The temperature rose slowly during the forenoon, and at 1:17 p. m. a light rain began falling. Soon sleet accompanied the rain, and later the rain ceased so that sleet alone fell. Some of the icy particles were nearly cubiform, measuring about one-fourth inch (0.64 centimeter) either way and mixed with them was the usual sleet—small spheres of frozen rain. At 5:25 p. m. moist snow fell with sleet. There was nothing unusual about the first falls of flakes, but the sleet immediately diminished in volume and as this occurred the flakes increased in size until they attained unusually large dimensions. They were of irregular shape, usually oblong; several were observed whose greatest diameters could hardly be covered by a teacup (perhaps about 7.6 centimeters). Some of these flakes were caught upon a piece of dry wood and examined; in every instance they showed the center to consist of a soft mass of snow about one-half inch (1.3 centimeters) in diameter, while the outer edges were thin, as though they were separate flakes that had attached themselves to the central mass while it was falling. The greater weight of the center caused the larger flakes to assume the form of an inverted cone as they fell, the outer, thinner edges being bent upward by the resistance of the air. Three of the large flakes were caught in a bowl and when melted yielded nearly a tablespoonful (14½ cubic centimeters?) of water. The flakes were widely separated from one another and did not obscure the vision when looking upward toward the sky.—[C. A., jr.]

[1] Otto Baschin *in* Meteorologische Zeitschrift, Feb. 1915, **32**: 93.
[2] E. J. Lowe. Snowstorm of January 7, 1887. Nature, London, 1887, **35**: 271.
[3] A letter in the "New York World" of Feb. 14, 1887, quoted by Samuel Lockwood in Nature, London, 1887, **35**: 414.

[4] See MONTHLY WEATHER REVIEW, January, 1891, **19**: 11.
[5] See MONTHLY WEATHER REVIEW, April, 1900, **28**: 156.

SECTION III.—FORECASTS.

STORMS AND WARNINGS FOR FEBRUARY.

By EDWARD H. BOWIE, District Forecaster.

[Dated: Washington, Mar. 13, 1915.]

The month opened with three low-pressure areas on the map; the first over Nova Scotia whence during the next 24 hours it passed from the region of observations, the second over northern Missouri, and the third on the extreme north Pacific coast. High-pressure areas were central as follows: Near Bermuda, over the northern Plains States with an extension eastward along the northern border to Quebec, and on the south Pacific coast.

The Missouri low-pressure area on the morning of the 2d showed two centers, one over southern Indiana and the other over eastern Ohio. The general disturbance advanced to the Virginia coast by the 3d and during the 24 hours following passed out to sea. General precipitation attended this disturbance over almost the entire country, heavy rains being reported from the Ohio Valley and portions of the Gulf States and heavy snow and sleet in portions of the upper Mississippi Valley, the Lake region and New England. At Yankton, S. Dak., during the 24 hours ending at noon of the 1st, the snowfall was 20 inches, the heaviest of record at this station. On the Atlantic coast high winds occurred during the 2d, 3d, and 4th, storm warnings having been previously issued.

The low area hereinbefore referred to was followed by the high which on the 1st of the month was over the northern Plains States and southern Canada. This high moved eastward along the northern border to the mouth of the St. Lawrence by the evening of the 2d, causing decided changes to colder weather and frosts along the middle and east Gulf coasts and in northern Florida, warnings of which were disseminated previously to their occurrence.

The low area that was on the extreme north Pacific coast on the 1st, passed east-northeastward to Alberta by the morning of the 2d at which time another low area of greater intensity was central on the middle Pacific coast. The Pacific coast low moved to northeastern Wyoming and during the next 24 hours a secondary developed which on the morning of the 4th was over northeastern Kansas. During the next three days it moved northeastward to eastern Quebec, while in its trough a secondary developed which, on the evening of the 2d was near Nantucket and on the following morning off the Maine coast. It passed north-northeastward during the following 24 hours. The storm was a producer of general rains. Winds of gale force occurred on the Pacific coast, storm warnings being issued before their occurrence.

This disturbance was followed by a high-pressure area that first appeared on the south Pacific coast and advanced northward and eastward to southwestern Wyoming by the 6th. On the 7th there were two centers, one over southwestern Texas and Colorado and the other over South Dakota. The southern center passed to the west Gulf coast with decreasing intensity while the northern center moved to the upper Lakes by the 9th and thence southeastward to the south Atlantic coast by the 12th. The frosts reported along the middle and east Gulf coasts and in northern Florida in connection with this high pressure were successfully announced in the forecasts.

There was a reaction to lower pressure followed by the appearance of a high over Manitoba on the 11th. This high moved eastward along the northern border to a position south of Nova Scotia by the 15th.

Following its passage a low pressure area from the north Pacific Ocean appeared on the evening of the 8th off the Washington coast. During the succeeding 12 hours it moved northward, thence moving south-southeastward to Nevada by the 10th and by the 12th to Colorado. From Colorado it passed eastward and northeastward to the Hudson Bay region during the next three days. An offshoot from this storm appeared on the evening of the 13th over the Rio Grande Valley and moved eastward across the Gulf of Mexico. After reaching southeastern Florida on the evening of the 16th, it moved northeastward, passing north of the Bermudas during the 19th. In connection with these disturbances precipitation occurred over the greater part of the country. In the Missouri Valley high winds caused the snow to drift to the extent of seriously interfering with railway traffic. High winds occurred on the Pacific coast and were fully covered by warning advices. On the 12th warnings for high winds were disseminated for the Texas coast and winds of storm character occurred during the succeeding 24 hours. In connection with the low that passed across the Gulf and thence northeastward near Bermuda, warnings for moderate to fresh gales off the south Atlantic coast were issued on the morning of the 17th and, although Hatteras was the only station reporting really high winds, gales undoubtedly occurred off the coast. Warnings were issued on the 18th for the north Atlantic coast and gales occurred as indicated.

A high pressure area was on the middle Pacific coast on the 12th, passed thence northward to western Washington by the evening of the following day. It then advanced eastward and southeastward to Missouri by the 16th and thence slowly northeastward to the St. Lawrence Valley with increased intensity by the 20th and to New Brunswick by the 22d.

A secondary low-pressure area that developed over eastern Colorado moved southward to Texas by the evening of the 18th and thence northeastward to Missouri, where it lost its identity.

A high-pressure area moved from Alberta on the morning of the 18th to Manitoba by the 19th and thereafter lost its identity.

Following the disintegration of the low and high just mentioned, a development occurred over Nevada during the 18th and a low of slight intensity was over Arizona by the evening of the 19th. It moved eastward to Oklahoma during the next 24 hours and thence northeastward to northeastern Iowa by the 22d, where it disappeared during the following 12 hours. It was immediately followed by a north Pacific low area that was central on the evening of the 19th over western Oregon and moved thence southeastward during the following 48 hours to Arizona. After passing to Oklahoma it moved northeastward to Lake Michigan by the 24th. An offshoot from this storm was central near the mouth of the Mississippi River on the 23d, whence it moved northeastward and northward up the Atlantic coast to Newfoundland by the 28th. Precipitation occurred generally through-

out the country, except in the northern Rocky Mountain region, heavy snows being reported in parts of Kansas, Iowa, and surrounding States with consequent damage to telegraph and telephone lines and delay to railway traffic. On the 24th storm warnings were ordered for the middle and north Atlantic coast and gales occurred as indicated in the advices. In connection with the passage of this disturbance, temperatures occurred at points from the lower Lake region eastward that were within a few degrees of the highest ever before recorded during the month of February.

On the evening of the 20th pressure was high over Saskatchewan and by the 22d a high pressure area was over Manitoba, whence it passed to the Canadian Maritime Provinces by the 24th. Another high-pressure area appeared over eastern Manitoba on the 24th and remained nearly stationary in that region for several days. On the 27th it was over northern Lake Superior, whence it moved southward to northeastern Texas by March 1. It later lost intensity over the lower Mississippi Valley.

On the evening of the 24th an offshoot from a low-pressure area, that was central on that morning on the north Pacific coast, was over the southern Plateau and during the following two days passed southeastward to the Valley of the Rio Grande. At the end of the month it occupied a position off the northern coast of eastern Florida, having caused precipitation over the Pacific and Plains States and over southern districts from the Rocky Mountains eastward.

At the end of the month pressure was low off the northern coast of eastern Florida, the Grand Banks, and over the middle Plateau, while high pressure prevailed from the upper Mississippi Valley southward to Texas.

NORTHERN HEMISPHERE PRESSURE.

Alaska.—Pressure averaged above normal over western and below normal over central and eastern portions. The principal lows of the month occurred about the 3d, 6th, 10th, 14th–15th, and 18th; and highs about the 8th, 12th, and 25th. The pressure at Dutch Harbor remained above 30.00 inches, nearly one-half inch above normal, from the 10th to 16th, inclusive.

Honolulu.—Pressure averaged well above normal. Lows occurred on the 11th–12th, 15th, and 25th, none, however, being of importance. Highs occurred on the 2d–3d, 6th, 9th, 18th–20th, and 27th.

Azores.—Pressure at Horta averaged above normal. Lows occurred on the 1st, 3d, and 16th; and highs on the 8th–11th, 14th, and 17th to 20th.

Reports from Iceland and Siberia are not available.

SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS, FEBRUARY, 1915.

By ALFRED J. HENRY, Professor in charge of River and Flood Division.

[Dated: Washington, D. C., Mar. 25, 1915.]

The flood situation during February, 1915, became threatening in the Ohio Valley during the first week of the month, due to the combination of warm weather, and fairly heavy rains on a snow cover of several inches. The latter, during the closing week of the previous month ranged in depth from 3 to 12 inches over the northern tributaries in the upper portion of the watershed. The States of Kentucky and Tennessee were bare of snow with the possible exception of the northern slopes in mountain districts.

A low-pressure system advanced upon the Ohio Valley on January 30, 1915, causing a rise in temperature and precipitation in the form of rain in the lower portion of the watershed. The rain continued and became considerably heavier on the succeeding day and a pronounced rise in temperature over the northern tributary streams in Ohio and Indiana caused a large run-off from melted snow. The breaking up and gorging of the ice threatened serious damage at various points and it was deemed necessary to destroy ice gorges by the use of dynamite at several places. The advance of the low pressure system to the northeastward was retarded and thus precipitation which ordinarily is concluded within 36 hours persisted throughout the 1st and for a portion of the 2d, and in West Virginia on the 3d. By this time a second low-pressure system was approaching from the west. Precipitation from this second storm was in the form of rain, which began on the lower portion of the watershed on the 4th and passed beyond the upper portion on the 6th.

The flood wave was created by the heavier rains of January 31 and February 1, combined with the run-off from melting snow. It was not greatly affected by the second period of rain. In the upper reaches of the river, as at Pittsburgh, the stream rose rapidly in the 24 hours following 8 a. m. of the 1st. At that hour the stage was 4.5 feet; and at 8 a. m. of the 2d the stage was 23.7 feet, a rise of 19.2 feet. The crest of the wave was not reached until midnight of the 2d, 28.4 feet, or 6.4 feet above flood stage. The progress of the flood wave down stream is shown in the subjoined table.

TABLE 1.—*Daily gage readings (feet) during Ohio flood of February, 1915.*

Station.	Flood stage.	February, 1915.																Crest.		
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Stage.	Date.	Hour.
	Feet.																	*Feet.*		
Pittsburgh	22	23.7	**27.7**	19.5	14.2	11.9	11.3	9.9	8.4	6.8	5.6	5.2	5.7	9.0	11.0	14.8	14.4	28.4	3	12:30 a. m.
Wheeling	36	20.6	39.7	**41.0**	34.0	25.3	20.5	18.3	15.8	13.3	11.3	10.3	10.0	12.0	16.2	19.2	23.0	42.2	3	10:00 p. m.
Parkersburg	36	26.5	34.7	41.0	**42.0**	38.6	33.7	27.6	22.4	18.1	15.0	12.7	12.0	12.9	15.9	19.3	21.8	42.2	4	9:10 p. m.
Point Pleasant	40	27.9	39.9	47.4	**49.8**	44.1	46.7	42.2	37.3	29.4	23.3	18.6	15.4	14.6	15.8	18.7	22.6	49.8	5	7:31 a. m.
Huntington	50	28.9	39.7	47.4	50.6	**51.1**	50.0	47.1	42.3	36.0	29.2	23.4	19.1	17.3	17.8	20.0	23.5	51.1	6	8:00 a. m.
Catlettsburg	50	32.0	42.6	50.1	53.5	**54.1**	53.0	50.2	45.4	39.3	32.1	26.0	21.7	19.3	19.8	22.3	25.9	54.2	6	9:00 p. m.
Portsmouth	50	32.0	41.0	48.5	52.6	54.4	**54.5**	53.0	49.7	44.1	37.3	30.6	25.2	22.5	22.4	24.0	26.4	54.7	6	2:00 p. m.
Maysville	50	29.7	37.7	44.7	49.5	52.5	**53.4**	52.6	50.3	46.1	40.6	34.4	28.2	23.8	22.4	22.9	24.9	53.5	6	10:00 p. m.
Cincinnati	50	38.0	41.4	45.2	49.5	54.3	**55.8**	55.5	54.0	51.0	46.6	40.8	34.8	29.8	26.3	24.9	25.6	55.9	7	8:20 a. m.
Louisville	28	15.7	19.6	21.0	22.7	25.6	28.3	29.8	**29.9**	28.9	26.7	23.2	18.3	13.2	10.7	10.0	9.7	29.9	9	7:00 a. m.
Evansville	35	31.9	35.0	37.0	38.3	39.2	40.1	41.0	41.9	42.5	**42.6**	42.5	41.9	40.9	39.4	36.9	33.6	42.6	11	7:10 a. m.
Cairo	45	35.0	37.1	39.1	41.2	42.7	43.8	44.4	45.0	45.3	**45.6**	**45.6**	**45.6**	45.3	44.8	44.0	43.0	45.6	......	

It will be noticed that the lower portion of the river, as at Evansville, was in flood as early as the 3d and that it continued in flood throughout the period covered by the table. The river at Cairo passed the flood stage on the 9th and fell below again on the 15th. The flood, therefore, in the upper stretches of the river was of much less duration than in the lower portion of the river.

The flood thus described passed into the Mississippi beginning on the 9th. At that time the Mississippi, which, in the neighborhood of Cairo, was rising somewhat from the same causes that had produced the Ohio flood, was still almost 10 feet short of flood stage, and hence conditions were unfavorable for a great flood. The river at New Madrid, Mo., the first station on the Mississippi below Cairo, passed the flood stage on the 19th. At Memphis, the flood stage, 35 feet, was reached on the 13th; the crest stage of 36 feet on the 17th and 18th, falling below flood stage on the 22d. At Vicksburg, Miss., the river lacked 1.2 feet of flood stage at the close of the month. The crest stage, 44 feet, flood stage 45 feet, was reached on March 1, and with a falling river thereafter the menace of a flood in the lower Mississippi in the spring of 1915 largely disappeared.

The rains of the last few days of January and early in February also produced flood stages locally in the rivers of the Carolinas, the James River of Virginia, the rivers of southeastern Mississippi and northern Alabama; also freshet stages in the White River of Arkansas, the Grand River of Missouri, and the Illinois. The rivers of Michigan also reached freshet stages during the month, due mostly to the formation of ice gorges and the melting of snow.

During the closing week of the month a local flood occurred in the Mississippi River between Quincy, Ill., and Hannibal, Mo., due to the melting of snow in the Des Moines Valley; also in the last part of the month a moderate flood occurred in the Connecticut River and the smaller streams of northern New England, due to a short, rainy period in conjunction with the melting of the snow cover and the breaking up of the ice in the streams.

Considerable loss was sustained at a number of places and four persons lost their lives at Lisbon, N. H., in a rush of ice and water in the Ammonoosue River.

Probably the most destructive floods of the month occurred in the Sacramento River of California, due to prolonged and heavy rains over the upper headwaters of that river in the neighborhood of Red Bluff and Kennett, Cal., 30 and 29 inches, respectively, falling at those places during the month. Fortunately the main flood waves came out of the upper Sacramento and Stony Creek, the lower eastern tributaries not contributing largely to the flood waters.

The principal crest at Kennett occurred on the 2d as a result of four consecutive days of heavy rain at that point; 13 inches of rain having fallen in that period. The area covered by this unusually heavy fall was doubtless not great. A second and more general flood wave arose on the 9th; which, though less in volume than the first, was more general in the tributary streams.

There was some overflow in the vicinity of Red Bluff, but the greatest overflow occurred on the left bank of the river between Knights Landing and Colusa, due to the breaking up of the levees that protected Colusa Basin. Local Forecaster Taylor, of Sacramento, furnishes the statements of the number of acres flooded and the loss occasioned by the flood given by Table 2.

TABLE 2.—*Losses due to floods in the Sacramento.*

	Acres.
Total flooded area	150,000
Planted to grain	40,000
Planted to alfalfa	5,000
MONEY LOSS.	*Dollars.*
Crop, seeded	140,000
Levees	100,000
Personal property, houses, fences, etc	50,000
Live stock, cattle, sheep, and hogs	5,000
Railroads, including that due to suspension of business	50,000
Total loss	345,000
Money value saved as result of warnings	35,000

The loss in connection with crops will be much greater provided the land flooded does not drain in time to allow replanting.

The approximate loss outside of California is shown by Table 3 below.

TABLE 3.—*Flood loss and damage, February, 1915.*

State or district.	Tangible property, bridges, highways, cleaning up.	Farm property, live stock.	Crops, prospective.	Suspension of business.	Estimated saved by warnings.
Ohio Valley:					
Pittsburgh district	$50,000			$10,000	$500,000
Parkersburg district				1,000	50,000
Cincinnati district	25,000	1,500		10,000	500,000
Evansville district	1,000	5,000	$3,750	5,000	50,000
South Carolina		100	200	200	14,000
North Carolina	1,500			2,000	5,000
Connecticut Valley	11,000				
James River at Richmond, Va	100			5,000	8,000
Pearl River of Mississippi	1,600	1,500		5,300	6,000
Total	89,600	7,100	3,950	38,500	1,133,000

Hydrographs for typical points on several principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

SNOWFALL AT HIGH ALTITUDES, FEBRUARY, 1915.

Arizona.—At high elevations such as the San Francisco peaks, Bill Williams Mountain, the higher ranges of Yavapai County and the higher levels of the Graham, and the ranges still farther south, where the precipitation was wholly or mostly in the form of snow, unusual depths are reported.

In the Mogollons, the White and Blue Mountains, and over a large extent of plateau bordering thereon, there have been frequent and heavy snows, with practically no melting. As a result the snow depths at altitudes above 7,500 feet have been increased phenomenally. In the Paradise Creek section of the White Mountains snow stakes were installed some months ago at elevations ranging from 8,000 to 9,800 feet. In this section the average depth of snow on January 28, 1915, was 30 inches. On March 3, less than three weeks later, three stakes were found buried in the snow. The stakes are set vertically in the ground, the tops 90 inches above the surface. In other parts of the field there was practically 9 feet of snow on the ground. There is, therefore, vastly more snow available for runoff this season than in the past, and it is difficult to conceive that the spring melting can occur under weather conditions so unfavorable as to possibly affect the realization of the confidently expected capacity storage in the Roosevelt Reservoir this spring.—*Robert R. Briggs, Section Director.*

California.—The snowfall during the month was very light and confined to the last decade. There is more snow on the ground than at this time last year, and also more than the normal. The snow is hard and well packed and the indications are that there will be ample water for irrigation and power purposes during the coming summer.—*G. H. Willson, District Forecaster.*

Colorado.—The snowfall during February was much below the normal throughout the regions drained by the Yampa, White, and Grand Rivers. On the Gunnison watershed the distribution was irregular, the fall being somewhat above the normal in the upper drainage of the north fork and below the normal in the upper part of the trunk stream. An excess occurred in the South Platte watershed, except near the headwaters, while a slight excess occurred in the middle drainage of the Arkansas, but there was a deficit in the Lake County district, where this river has its source. In general, slightly more than the average snowfall occurred in the Rio Grande drainage area, and a moderate excess in the San Juan and southwestern areas.—*F. H. Brandenburg, Section Director.*

Idaho.—The month of February was one of light snowfall. While the precipitation was normal or above in many places, the greater part of it was in the form of rain, except in the higher mountains. The temperature was generally much above normal, resulting in rapid melting. In all parts of the State there is less than the average amount of snow, and in many places the depth is less than for years at this date. The melting thus far has caused little runoff. The snow is fairly wet, averaging about 28 per cent of its depth in water, where measurements of density have been made. The present outlook is for a decided shortage in the flow of all the streams of the State.—*Edward L. Wells, Section Director.*

Montana.—February was the fourth month with light snowfall throughout Montana. There is practical agree-

ment in a large number of reports from elevated regions that the accumulated depth of snow in the mountains at the close of the month was much below the average. The precipitation records for late fall and winter fully confirm this view of the conditions, since the accumulated deficiency of the last four months is very pronounced in every part of the State. At lower levels the ground has been bare of snow most of the winter, except over a comparatively small area in the north central portion.—*R. F. Young, Section Director.*

Nevada.—February was noteworthy for its frequent and heavy snowstorms. The snowfall was considerably above the normal, particularly in the Sierras. In the Truckee, Carson, and Walker Basins more precipitation occurred in February than in the five preceding months put together. By the close of the month the great deficiency noted at the termination of January, 1915, had been reduced appreciably, though not entirely offset. The general condition of the snow on the ground was reported as loose and favorable for early melting. The prospects for an ample supply of water for irrigation this summer are good.—*H. F. Alciatore, Section Director.*

New Mexico.—The snowfall of February averaged more than 8 inches for the entire State, despite the fact that little or no snow occurred over the lower levels of the southern tier of counties. The seasonal average fall is thus 27.5 inches, or almost 10 inches in excess of the normal, and nearly 5 inches greater than at a like period last season. The mountain areas were well favored, the central and southern especially. Observers report the largest snowfall for several years in the Capitan, White, and Manzano Mountains. The continuation of the cool, comparatively cloudy, wet season, begun in December has been highly favorable to the State in conserving the moisture and adding to the stored depth.

Considerable improvement has occurred over the Canadian and Northeast ranges, and the stored depth over the main range now indicates a fair early flow in that stream. The snowfall over the higher areas tributary to the Pecos, the San Francisco, Gila and Mimbres, Zuñi, and the Rio Grande in New Mexico was large and has further improved conditions on these streams, indicating a good early flow. Improvement has also occurred over the northeast tributaries of the San Juan, and this stream will no doubt have abundant water for all its demands.—*C. E. Linney, Section Director.*

Oregon.—Snowfall was light and by the end of the month many of the south and west slopes of the Cascade range were bare and there was practically no snow on the ground in the cultivated valleys. Fears are entertained that there will be a shortage of water late in the spring for irrigation and placer mining.—*E. A. Beals, District Forecaster.*

South Dakota.—The average snowfall in the Black Hills region, as well as elsewhere in the State, was near normal, but the average amount on ground at the end of March was greater than the normal. Gulches are filled with snow, and in many places thawing and freezing have changed the snow to ice. The outlook for spring soil moisture generally, and for water for irrigation purposes in the Black Hills region, is excellent. Stream flow is somewhat greater than normal, but melting snow has been largely absorbed by the ground.—*M. E. Blystone, Meteorologist.*

Utah.—Substantial gain was made in the accumulated amounts of snow in the mountains and hills of Utah during February. In both the Sevier Lake and the southern portion of the Colorado River watershed the snow is well packed and in favorable condition for late keeping. In Great Salt Lake watershed the available snow is still not up to the normal and the conclusion is drawn that the prospective water supply is less than the average amount.—*A. H. Thiessen, Section Director.*

Wyoming.—Snow depths were substantially increased on the watersheds of the Big Horn, Green, North Platte, Powder, and Snake Rivers during February, but on the watersheds of the Cheyenne, Tongue, and upper Yellowstone there was but little improvement.—*R. Q. Grant, Section Director.*

Washington.—February, 1915, was very similar to February, 1914, in mildness of the weather and deficiency in snowfall. The snowfall in the mountains of Washington was, on the whole, less than in any former February since regular records began.—*G. S. Salisbury, Section Director.*

MEAN LAKE LEVELS DURING FEBRUARY, 1915.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., Mar. 4, 1915.]

The following data are reported in the Notice to Mariners of the above date:

Data.	Lakes.			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during February, 1915:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	601.70	579.54	571.41	244.99
Above or below—				
Mean stage of January, 1915	− 0.11	+ 0.10	+ 0.32	+0.29
Mean stage of February, 1914	− 0.51	− 0.54	− 0.30	−0.88
Average stage for February, last 10 years	− 0.09	− 0.54	− 0.27	−0.78
Highest recorded February stage	− 0.78	− 3.18	− 2.34	−2.68
Lowest recorded February stage	+ 0.94	+ 0.38	+ 0.78	+1.16
Probable change during March, 1915	− 0.2	0.0	+ 0.1	+0.1

SECTION V.—SEISMOLOGY.

SEISMOLOGICAL REPORTS FOR FEBRUARY, 1915.

W. J. HUMPHREYS, Professor in Charge of Seismological Investigations.

[Dated: Washington, D. C., Mar. 31, 1915.]

TABLE 1.—*Noninstrumental earthquake reports, February, 1915.*

Day.	Approximate time. Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
	h. m.		° ′	° ′			m. s.			
16	13 30	Julian	33 05	116 37	5	1	6	Rumbling		J. H. L. Vogt.
17	11 00	Cahuilla	33 32	116 43	3	1	2	Rumbling		Dr. W. L. Shawk.
18	9 47	Eureka	40 48	124 11	2	1	Few.		Sudden jolt	U. S. Weather Bureau.
	9 47	Rohnerville	40 33	124 11	4	1				W. D. Gray.
21		Redding	40 36	122 27	7	Many.	1 0		30 miles east of Redding.	J. H. Buick.
28	11 00	Arbolado	36 15	121 47	5	2	6	Rumbling		Forest Service.
	11 00	Hollister	36 50	121 20	4	1	12			J. N. Thompson.
	11 00	Spreckels	36 20	121 48	3	1	10			J. K. Scott.
		COLORADO.								
28	7 51	Grand Junction	39 09	108 33	1	1	?			Whipple Chester.
		ILLINOIS.								
5	6 55	Equality	37 45	88 22	2	1	1	Rumbling		L. W. Gordon.
	6 55	Harrisburg	37 45	88 34	4-5	1	1 0	Rumbling	Shook buildings	Clarence Bonnell.
19	4 35	Cairo	37 00	89 10	2	1	3			U. S. Weather Bureau.
	4 35	Mound City	37 09	89 10	4	1	3		Shook buildings	Press at Cairo, Ill.
		MASSACHUSETTS.								
21	1 59	Haverhill	42 47	71 05	3	1	2	Rumbling		Press at Haverhill.
	1 59	Lawrence	42 41	71 10	2	1	15			Richard A. Hale.
	2 03	Lowell	42 39	71 20	2	1				Press at Boston.
	2 21	Andover	42 42	71 08	4	1		Rumbling	Shook buildings	Press at Boston.
	2 21	Haverhill	42 47	71 05	4	1	2	Rumbling	Felt in southern New Hampshire.	Press at Haverhill.
	2 21	Lowell	42 39	71 20	4	1				Press at Boston.
	2 30	Andover	42 42	71 08	4	1		Faint		Press at Boston.
	2 30	Lawrence	42 41	71 10	4	1	15	Rumbling	Shook buildings	Richard A. Hale.
	2 35	Andover	42 42	71 08	2	1		Rumbling		Press at Boston.
	2 45	Andover	42 42	71 08	2	1		Rumbling		Press at Boston.
		NEVADA.								
9	23 10	Gerlach	40 26	119 41	2	1	5		Shook oil in lamps	A. T. Dauterman.
	23 10	Sand Pass	40 18	119 48	2	1	5			R. R. Mott.
		NEW YORK.								
21	23 41	Beekmantown	44 45	73 24	3-4	1	8	Rumbling		Geo. K. Pardy.
	23 41	Beekmantown	44 45	73 24	3	1	3			Mary Callunan.
		UTAH.								
12	19 50	Enterprise	37 35	113 50	3	1	50	Loud		Jas. E. Hall.
13	8 30	Enterprise	37 35	113 50	3	1				Jas. E. Hall.
		WASHINGTON.								
11	3 07	Queets River	47 30	124 15	3	1	30			C. A. Bullard.
28	18 00	Lakeside	47 50	120 01	3	1				W. H. Van Meter.
		PORTO RICO.								
1		Arecibo	18 28	66 44	3	1	Few.	Rumbling		W. J. Young.
3	11 18	Arecibo	18 28	66 44	3	1	Few.	Rumbling		W. J. Young.
17	13 35	Arecibo	18 28	66 44	4	1	8	Rumbling	Shook buildings	W. J. Young.
	13 35	Lares	18 23	66 55	2	2				Paul Vilella, jr.
	13 35	Mayaguez	18 13	67 09	4-5	1	6	Rattling		P. R. Expt. Station.

TABLE 2.—*Instrumental reports.*

[Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.]

[For significance of symbols see this Review, December, 1914, p. 689.]

Arizona. Tucson. Magnetic Observatory. U. S. Coast and Geodetic Survey. F. P. Ulrich.

Lat., 32° 14′ 48″ N.; long., 110° 50′ 01″ W. Elevation, 769.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kilograms.

Instrumental constants: V, T_0 — E: 10, 16; N: 10, 19.6

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
Jan. 12	I_u	P_E	4 35 18	3				
		eN	4 35 36	4				
		M	4 36 30	10	30	10		
		C	4 39 00	6				
		F	4 46 00	4				
13		L	7 35 00	30				
		M	7 38 00	30	10	10		
		C	7 48 00					
Feb. 14		eE	11 34 09					No motion discernible on N.
		M_E	11 35 54	11	10			
		F	11 37 00					
25		P_E	20 57 05	4				
		M	20 57 25	8	50	10		
		F	21 01 00	5				

Colorado. Denver. Sacred Heart College Earthquake Station. A. W. Forstall, S. J.

Lat., 39° 40′ 36″ N.; long., 104° 56′ 54″ W. Elevation, 1,655 meters.

Instrument: Weichert, 80 kilograms, astatic, horizontal pendulum.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
Jan. 11			5 30 ..					Quake reported from Santa Barbara, Cal. Possibly slight record here at hour marked.
			6					
28			5					Activity—Thickening of pen marks.
			7					
Feb. 4			16 13 ..					Long period, very weak waves. Activity during day. Rather doubtful.
9			16					Wavelets on E-W, but very irregular and somewhat doubtful.
			19 ends.					
13			2					Activity at hours marked, but doubtful. Heavy machinery in motion near by.
			4					
14			10					Possible activity.
			11					
22			12					Very small waves, long period, both components.
			14					
25			1					Long-period waves on E-W.
			3 ends.					
28			(?)					Long-period waves, very weak, especially on N-S.

Maryland. Cheltenham. Magnetic Observatory. U. S. Coast and Geodetic Survey. George Hartnell.

Lat., 38° 44′ 00″ N.; long., 76° 50′ 30″ W. Elevation, 71.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kilograms.

Instrumental constants: V, T_0 — E: 10, 31; N: 10, 29

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
Jan. 5		P_N	23 46 07					No motion discernible on E.
		L_N	23 55 00	16				
		M_N	23 56 45	14		40		
		C_N	23 59 00					
		F_N	24 55 00					
13		L_N	7 25 00	20				No motion discernible on E. Well-defined microseisms for several hours earlier and later.
		M_N	7 28 00	20		20		
		F_N	7 37 00					
Feb.								No earthquake recorded during February. Microseisms on Feb. 2.

Massachusetts. Cambridge. Harvard University Seismographic Station. J. B. Woodworth.

Lat., 42° 22′ 36″ N.; long., 71° 06′ 59″ W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.

Instruments: Two Bosch-Omori, 100 kilogram, horizontal pendulums (mechanical registration.)

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
Feb. 7		*0*[1]	*5 16 30*				15	Local shock: Not reported by persons.
		iP_N	5 16 32					
		iM	5 16 34					
		F	5 16 50					
16		*0*	*17 05 26*				85	Not heard from.
		iP	17 05 38					
		M	17 05 48					
		F	17 05 54					
16		*0*	*19 24 39*				100	Not heard from.
		P	19 24 53					
		M	19 25 05					
		F	19 25 18					
19		*0*	*22 24 58*				90	Not heard from.
		P	22 25 10					
		M	22 25 20					
		F	22 26 52					
20		*0*	*15 36 37*				20	Not reported as felt.
		iP	15 36 40					
		M	15 36 42		10			
		C	15 36 50					
		F	15 37 06					
20		*0*	*19 54 13*				95	Not heard from.
		iP	19 54 18					
		L	19 54 37					
		C	19 55 02					
		F	19 55 18					
20		*0?*						Not heard from. Deflection N. No. M.
		P_N	23 08 38					
		F	23 09 48					

[1] *0* indicates time of occurrence at origin, calculated from Brit.

TABLE 2.—*Instrumental reports*—Continued.

Massachusetts. Cambridge. Harvard University Seismographic Station. J. B. Woodworth—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Feb. 21	......	*0*......	0 39 08	......	......	......	......	Not heard from.
		iP_N...	0 39 15	......	......	......	......	
		L.....	0 39 21	6	......	......	......	
		M.....	0 39 34	......	......	6	......	
		F.....	0 39 42	......	......	......	......	
21	......	*0*......	....				70	Not heard from.
		P.....	1 20 11	......	......	......	......	
		L.....	1 20 19	......	......	......	......	
		F.....	1 21 01	......	......	......	......	
21	......	*0*......	*1 56 58*	......	......	......	40	Felt in Haverhill, Mass. (45 kms.) at "8:55."
		P.....	1 57 06	......	......	......	......	
		L.....	1 57 10	......	......	......	......	
		M.....	1 57 12	......	......	......	......	
		F.....	1 57 22	......	......	......	......	
21	......	*0*......	1 57 49	......	......	......	45	Cf. preceding.
		P.....	1 57 57	......	......	......	......	
		L.....	1 58 05	......	......	......	......	
		F.....	1 58 16	......	......	......	......	
21	......	*0*......	....	......	......	......	......	Phases indistinct. No M. Lowell, Mass., reported shock felt at 9:05 p. m.
		P.....	2 02 46	......	......	......	......	
		F.....	2 03 46	......	......	......	......	
21	......	*0*......	*2 20 53*	......	......	......	20	Felt at Andover, Mass. Lowell reported shock felt at 9:30 p. m. (2:30 G. M. T.)
		P.....	2 20 55	......	......	......	......	
		L.....	2 20 58	......	......	......	......	
		F.....	2 21 17	......	......	......	......	
21	......	*0*......	*2 35 14*	......	......	......	30	Felt at Andover, Mass. (30 kms.). Another at 9:45 p. m. of which there is a trace on records (N).
		P.....	2 35 18	......	......	......	......	
		L.....	2 35 21	......	5	......	......	
		F.....	2 35 38	......	......	......	......	
21	......	*0*......	....	......	......	......	......	Phases indistinct.
		P_N....	3 09 30	......	......	......	......	
		F.....	3 09 36	......	......	......	......	
23	......	*0*......	*23 13 05*	......	......	......	145	
		P.....	23 13 25	......	......	6	......	
		L.....	23 13 42	......	......	......	......	
		F.....	23 14 10	......	......	......	......	
25	......	*0?*.....	*9 03 41*	......	......	......	3440	*0* from S-P. Phases masked by microseisms.
		P_E....	9 10 19	3	......	......	......	
		S.....	9 15 32	6	......	......	......	
		L_E....	9 25 19	12	......	......	......	A 0.25 mm. on record.
		L_N....	9 26 06	16	......	......	......	A 0.25 mm. on record.
		M.....	9 28 53	......	......	......	......	
		F.....	9 48 ..	......	......	......	......	
25	......	*0*......	*20 47 07*	......	......	......	9200	Phases masked by microseisms.
		P?....	20 59 42	......	......	......	......	
		....	21 01 34	......	......	......	......	
		iS.....	21 10 02	6	......	......	......	
		eL_N...	21 23 36	13	......	......	......	
		....	21 24 38	20	......	......	......	
		L_N....	21 46 07	20	......	......	......	
		F.....	21 48 ..	......	......	......	......	
25	......	*0*......	*22 14 06*	......	......	......	260	Not heard from.
		P.....	22 14 48	......	......	......	......	
		L.....	22 15 17	......	......	......	......	
		F.....	22 15 49	......	......	......	......	
28	......	*0?*.....	.. .. ..	......	......	......	......	P and S in microseisms.
		e......	19 38 20	7	......	......	......	
		....	19 39 30	6	......	......	......	
		L_E....	19 49 34	40	......	......	......	
		L.....	19 54 02	30	......	......	......	
		....	19 58 03	26	......	......	......	
		M.....	19 59 20	22	......	......	......	A 0.5 mm. on record.
		F.....	20 49 ..	......	......	......	......	

New York. Buffalo. Canisius College. John A. Curtin, S. J.

Lat., 42° 53′ 02″ N.; long., 78° 52′ 40″ W. Elevation, 190.5 meters.

Instrument: Wiechert, 80 kg. horizontal.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Jan. 10	......	....	18 00 00	10 to 15	150*	......	......	Earth tremors (per diem et noctem).
11	......	....	19 07 00	10	100 to 150*	......	......	Earth tremors—groups of 5 to 6 per min., average 18 per hour. Shocks reported from Santa Clara, Cal.
12	......	....	....	?	?	......	......	Same as above, but decreased amplitude and intensity.
13	I_u...	P........	....	......	......	......	7724	P not distinguishable from increased earth tremors. Reported from Italy. C of varying period during following 24 hours due either to reflected waves or minor shocks.
		iS.....	7 11 49	......	Small	......	......	
		N-PS?	7 23 34	15	......	400*	......	
		E-PS?	7 24 00	20	250*	......	......	
		eL_E...	7 28 34	30	300*	......	......	
		L_E....	7 29 00	26	550*	......	......	
		L_E....	7 30 00	30	500*	......	......	
		L_N....	7 29 00	20	......	350*	......	
		F_E....	7 37 00	......	......	......	......	
		F_N....	7 37 00	......	......	......	......	
14	......	....	....	......	......	......	......	Many microseisms on both components.
31	......	P.....	2 04 15	......	......	......	4506	S. doubtful.
		S.....	2 11 13	......	......	......	......	
Feb. 1	......	....	18 04 00	......	......	......	......	Earth tremors, N-S.
		....	18 07 00	......	......	......	......	
2	......	....	23 00 00	......	......	......	......	Earth tremors, N-S.
3	......	....	3 00 00	......	......	......	......	
4	......	L_E....	1 26 00	......	250*	......	......	Reported in England.
6	......	i?.....	21 25 00	......	......	......	......	Sharp shocks (2) from east.
9	......	....	....	......	......	......	......	Microseisms per diem, N-S.
10	......	iP.....	14 13 45	......	......	......	4024	Sharp shock, south.
		S.....	14 19 00	......	......	......	......	
11	......	iP.....	11 51 00	......	......	......	......	Sharp shock, south.
13	......	....	20 00 00	......	......	......	......	Earth tremors on N-S.
		....	22 00 00	......	......	......	......	
15	......	....	1 56 00	......	......	......	......	Earth tremors on N-S, 24 hours' duration.
15	......	eL_N...	19 42 00	15	Small	200*	......	
		F.....	19 45 00	......	......	......	......	
18	......	i?.....	0 30 00	......	......	......	......	Slight shock from W.
18	......	....	....	......	......	......	......	Slight shock from W. (No time, clock off.)
19	......	i?.....	0 12 30	......	......	......	......	Slight shock from W.
21	......	....	....	......	......	......	......	Intermittent tremors, N-S and E-W.
23	......	L.....	23 18 00	......	......	......	......	Earth tremors, a. m.
		L_N....	23 21 00	......	......	660*	......	
28	......	....	3 07 00	......	......	......	......	Earth tremors, N-S.
		....	3 12 00	......	......	......	......	
28	......	....	11 45 00	......	......	......	......	Earth tremors, N-S.
		....	11 48 00	......	......	......	......	

* Trace amplitude.

TABLE 2.—*Instrumental reports*—Continued.

New York. **Fordham. Fordham University.** W. C. Repetti, S. J.

Lat., 40° 51′ 47″ N.; long., 73° 53′ 08″ W. Elevation, 23.9 meters.

Instruments: Wiechert, 80 kilograms. Instrumental constant: T_0=6.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915			H. m. s.	Sec.	Mm.	Mm.	Km.	
Feb. 25	I....	iL_N....	10 20 20	......	......	......	......	Microseisms from 12h 00m 00s until 23h 00m 00s.
		L_N....	10 23 02	9	......	0.12	......	
		eL_E....	10 19 08	......	......	......	......	
		L_E....	10 17 42	13	0.12	......	......	
		F_N....	10 28 42	......	......	......	......	
		F_E....	10 27 57	......	......	......	......	

Vermont. **Northfield. U. S. Weather Bureau.** Wm. A. Shaw.

Lat., 44° 10′ N.; long., 72° 41′ W. Elevation, 256 meters.

Instruments: Two Bosch-Omori, mechanical registration.

Instrumental constants: $\begin{cases} E & 20 & 15 \\ N & 25 & 16 \end{cases}$ (V, T_0)

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915			H. m. s.	Sec.	μ	μ	Km.	
Feb. 25	......	L_N....	{9 24 30 / 9 27 45}	12	......	......	......	No marked maximum.
28	......	L_N....	{20 07 .. / 20 14 ..}	20	......	......	......	

Alaska. **Sitka. Magnetic Observatory.** U. S. Coast and Geodetic Survey. J. W. Green.

Lat., 57° 03′ 00″ N.; long., 135° 20′ 06″ W. Elevation, 15.2 meters.

Instruments: Two Bosch-Omori, 10 and 12 kilograms.

Instrumental constants: $\begin{cases} E & 10 & 17.4 \\ N & 10 & 15.6 \end{cases}$ (V, T_0)

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
Jan. 5	......	eP_E....	23 38 15	3	......	......	......	
		eL....	23 43 00	12	......	......	......	
		M.....	23 49 18	10	10	20	......	
		F.....	24 02 00	......	......	......	......	
13	......	eL....	7 31 40	16	......	......	......	
		M.....	7 39 45	18	10	10	......	
		F.....	7 50 00	......	......	......	......	Microseisms present on Jan. 1, 2, 8–11, and 16.

Hawaii. **Honolulu. Magnetic Observatory.** U. S. Coast and Geodetic Survey. Wm. W. Merrymon.

Lat., 21° 19′ 12″ N.; long., 158° 03′ 48″ W. Elevation, 15.2 meters.

Instrument: Milne seismograph of the seismological committee of the British Association. Instrumental constant: T_0=19.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
Jan. 3	......	eL....	0 39 48	......	......	......	......	
		M.....	0 47 48	18	200*	......	......	
		F.....	1 08 00	......	......	......	......	
4	......	eP....	0 37 18	......	......	......	......	
		eL....	0 44 36	25	......	......	......	
		M.....	0 52 48	18	300*	......	......	
		C.....	0 57 42	......	......	......	......	
		F.....	1 55 00	......	......	......	......	
4	......	eL....	22 44 00	23	......	......	......	
		M.....	22 55 30	20	......	......	......	
		C.....	23 06 00	......	100*	......	......	
5	......	P.....	15 42 24	......	......	......	......	
		S.....	15 49 12	......	......	......	......	
		L.....	15 53 24	21	......	......	......	
		M.....	15 55 00	20	1,500*	......	......	
		C.....	16 10 00	......	......	......	......	
		F.....	17 41 00	......	......	......	......	
5	......	P.....	23 38 12	......	......	......	......	Time may be in error by as much as 30 seconds.
		L.....	23 47 00	22	......	......	......	
		M.....	23 48 00	19	1,800*	......	......	
		C.....	24 32 00	......	......	......	......	
		F.....	26 20 00	......	......	......	......	
10	......	L.....	23 41 36	......	......	......	......	Doubtful.
		M.....	23 49 48	19	100*	......	......	
		F.....	24 33 00	......	......	......	......	
13	......	P.....	7 22 54	......	......	......	......	
		L.....	7 45 18	18	......	......	......	
		M.....	8 03 00	20	700*	......	......	
		C.....	8 30 00	......	......	......	......	
		F.....	10 43 00	......	......	......	......	

Hawaii. **Honolulu. Magnetic Observatory.** U. S. Coast and Geodetic Survey. Wm. W. Merrymon—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
Jan. 21	......	P.....	15 26 48	......	......	......	......	
		S.....	15 37 48	......	......	......	......	
		L.....	15 45 30	20	......	......	......	
		M.....	15 55 12	19	100*	......	......	
		C.....	16 00 00	......	......	......	......	
		F.....	16 13 00	......	......	......	......	
21	......	L.....	21 49 24	22	......	......	......	
		M.....	21 56 24	21	200*	......	......	
		F.....	22 33 00	......	......	......	......	
30	......	eL....	8 14 06	......	......	......	......	
		M.....	8 14 36	20	100*	......	......	
		F.....	8 55 00	......	......	......	......	
Feb. 7	......	L.....	22 18 54	......	......	......	......	
		M.....	22 28 54	18	300*	......	......	
		C.....	22 35 54	......	......	......	......	
		F.....	23 01 18	......	......	......	......	
10	......	L.....	4 20 30	......	......	......	......	
		M.....	4 23 12	18	100*	......	......	
		F.....	4 34 30	......	......	......	......	
17	......	P.....	15 30 18	......	......	......	......	
		L.....	15 40 48	......	......	......	......	
		M.....	15 42 36	20	200*	......	......	
		C.....	15 46 36	......	......	......	......	
		F.....	15 51 06	......	......	......	......	
25	......	eP....	9 16 54	......	......	......	......	
		L.....	9 19 06	......	......	......	......	
		M.....	9 20 54	20	400*	......	......	
		C.....	9 25 54	......	......	......	......	
		F.....	10 22 54	......	......	......	......	
25	......	L.....	14 18 18	24	......	......	......	
		M.....	14 22 54	20	200*	......	......	
		C.....	14 28 42	......	......	......	......	
		F.....	15 26 54	......	......	......	......	
25	......	P.....	20 43 48	......	......	......	......	
		L.....	20 49 30	......	......	......	......	
		M.....	20 49 48	20	1,700*	......	......	
		C.....	21 12 24	......	......	......	......	
		F.....	22 15 00	......	......	......	......	
26	......	eL....	3 23 54	21	......	......	......	
		M.....	3 28 06	18	300*	......	......	
		C.....	3 34 18	......	......	......	......	
		F.....	3 56 36	......	......	......	......	
28	......	P.....	19 19 54	......	......	......	......	
		L.....	19 32 18	27	......	......	......	
		M.....	19 40 24	18	2,000*	......	......	
		C.....	19 59 24	......	......	......	......	
		F.....	22 07 00	......	......	......	......	

Canada. **Ottawa. Dominion Astronomical Observatory Earthquake Station.** Otto Klotz.

Lat., 45° 23′ 38″ N.; long., 75° 42′ 57″ W. Elevation, 83 meters.

Instruments: Two Bosch photographic horizontal pendulums, one Spindler and Hoyer 80 kg. vertical seismograph.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	Sec.	μ	μ	Km.	
Feb. 25	......	P.....	9 11 22	......	......	......	3000?	
		S_E?...	9 15 43	......	......	......	......	
		eL_E...	9 23 03	20	......	......	......	
		L.....	{9 25 to / 9 28}	{14 to / 18}	......	......	......	
		F.....	9 40	......	......	......	......	
25	......	iP.....	20 59 28	3	......	......	9150	
		i.......	21 01 41	......	......	......	......	
		iS?....	21 09 46	......	......	......	......	
		eL_N...	21 23 03	40	......	......	......	
		F.....	21 45	......	......	......	......	
26	......	......	......	......	......	......	......	Between 1h and 2h 30m disturbances occur which, however, can not be identified with any phases and again between 12h and 15h.
28	......	PR_1?..	18 59 00	......	......	......	13000+	
		iSR_1?.	19 18 08	......	......	......	......	
		iSR_3?.	19 27 30	......	......	......	......	
		eL....	19 45 07	40	......	......	......	
		L.....	19 50	40	......	......	......	
		L.....	19 55	27	......	......	......	
		L.....	{20 01 to / 20 16}	{24 to / 18}	......	......	......	
		F.....	20 35	......	......	......	......	

*Trace amplitude in millimeters.

TABLE 2.—*Instrumental reports*—Continued.

Canada. Toronto. Dominion Meteorological Service.

Lat., 43° 10′ 01″ N.; long., 79° 23′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, north. In the meridian.

Instrumental constants: $T_0=18$.

1 millimeter swing of boom=pillar deviation of 0.59″.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Feb. 25		P	9 13 00				3350	After 9^h 24^m 30^s, vibrations gradually decreased. Abrupt increase at 9^h 24^m 12^s.
		P	9 15 36					
		SR	9 17 18					
		L	9 23 00					
		iL	9 24 12					
		M	9 24 30		400			
		F	9 31 06					
25		L	15 23 00					Phases not defined.
		F	15 33 00		50			
25		P	20 54 48					Appearance of air currents at 20^h 46^m 36^s. Air currents mixed up with movements at 21^h 41^m 42^s.
		iS	21 00 06					
		iL	21 03 24					
		M	21 04 42		300			
		iL	21 22 30					
		iL	21 34 36					
		iL	21 38 06					
		F						Air currents.
28		P	19 24 54					
		S	19 33 06					
		S	19 40 54					
		iS	19 45 54					S waves prolonged.
		iL	19 55 24					
		L	20 00 24					
		M	20 03 12		500			
		iM	20 07 24		400			
		iL	21 04 00					
		F	21 24 00					

Canada. Victoria. Dominion Meteorological Service.

Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: Rock.

Instrument: Milne horizontal pendulum, north. In the meridian.

Instrumental constants: $T_0=18$.

1 millimeter swing of boom=pillar deviation of 0.54″.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Feb. 25		P	9 03 37				800	
		L	9 05 37					
		M	9 06 37		1200			
		F	9 18 37					
25		P	15 07 07					
		L						
		M	15 08 07		200			
		F	15 11 33					
25		P	20 51 02					
		S	20 55 02					
		L	20 57 02					
		M	20 57 32		500			
		iL	21 23 24					
		F	21 47 32					
28		P	19 22 21					
		S	19 27 51					
		L	19 46 51					
		M	20 03 21		500			
		F	20 35 21					

SECTION VI.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in charge of Library.

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Qualche dato intorno all'effetto utile delle precipitazioni per l'alimentazione dei corsi d'acqua. Firenze. 1914. 4 p. 24 cm. (Estratto dalla Rivista geografica italiana, anno 21, fasc. 3, 1914.)

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Om naturens värmehushållning. Uppsala. 1914. 299–325 p. 21½ cm. (*Reprint*: K. Vetenskapsakademiens årsbok, årg. 12, 1914.)

Harvard seismographic station.
Fifth annual report including records, 1 August, 1912–31 December, 1913, by J. B. Woodworth. Cambridge, Mass. 1914. 55–77 p. 24½ cm. (Bulletin of the Museum of comparative zoölogy at Harvard college, v. 55, no. 3.)

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Surface formations and agricultural conditions of northwestern Minnesota. With a chapter on climatic conditions of Minnesota, by U. G. Purssell. Minneapolis. 1915. vi, 78 p. plates. 22½ cm. (Minnesota geological survey. Bulletin no. 12.)

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Results of meteorological, magnetical, and seismological observations, 1914. Blackburn. 1915. xxi, 52 p. plate. 18½ cm.

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Thoroddsen, Th[orvald].
An account of the physical geography of Iceland. Copenhagen, *etc.* 3 p.l., 191–343 p. 26 cm. (The Botany of Iceland, ed. by L. K. Rosenvinge, and Eug. Warming. Part I, [no.] 2.) [Climate, p. 266–291.]
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Bulletin des observations. Tome 36, année 1910. Météorologie. Chang-hai. 1914. xxxiii, 153 p. plates. 31 cm.
Bulletin des observations. Tome 36, année 1910. Sismologie. Chang-hai. 1914. 18 p. 31 cm.

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Professor in charge of Library.

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Davison, Charles. The earthquake in central Italy on January 13. p. 145–146.

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Harwood, W. A. A discussion of the anemographic observations recorded at Port Blair from September, 1894, to August, 1904. p. 141–189.
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Krebs, Wilhelm. Echo aus der Hochatmosphäre. Hörweite des Schlachtendonners an der Nordseeküste und die Frage des dortigen Seedonners. p. 24. (24. Feb.) [Explains Mistpoeffers as echoes from a boundary plane in the upper atmosphere.]
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NOTES FROM THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

THE SINGULAR OF "SASTRUGI."

In the glossary prefixed to "Scott's Last Expedition" (New York, 1913, vol. 1, p. xxiii) occurs the following definition:

> *Sastrugus.* An irregularity formed by the wind on a snow plain. "Snow wave" is not completely descriptive, as the sastrugus has often a fantastic shape unlike the ordinary conception of a wave.

The word *sastrugus*, which also occurs in the text of Capt. Scott's diary, is apparently his own back-formation from the familiar plural *sastrugi*, on the hasty assumption that the latter term is Latin or is susceptible of a Latin inflection. This is a curious blunder.

The term *sastrugi* is exceedingly common in current polar literature, where it supplies a name for a snow formation characteristic of wind-swept plains; especially those where the winds tend to blow constantly in one direction, so that the sastrugi, or snow ridges, are more or less permanent and serve to indicate the points of the compass. This characteristic of the snow ridges in northern Siberia was noted nearly a century ago by Baron von Wrangel, and the Russian name for these ridges, *zastrugi*, Germanized to *sastrugi*, was made

familiar by the narrative of Wrangel's travels compiled from the latter's journals and published by Engelhardt in 1839. An English translation (by Mrs. Sabine), of Engelhardt's book (notable for the fact that neither the compiler's nor the translator's name appears on the title-page) appeared in 1840, and in it the German spelling of the above term was preserved. Wrangel's description of sastrugi follows:[1]

To enable us to follow as straight a line as possible, we tried to fix our eyes on some remarkable piece of ice at a distance; if there was none such, we were guided by the wavelike stripes of snow (sastrugi) which are formed, either on the plains on land or on the level ice of the sea, by any wind of long continuance. These ridges always indicate the quarter from which the prevailing winds blow. The inhabitants of the Tundras often travel to a settlement several hundred versts off with no other guide through these unvaried wastes than the sastrugi. They know by experience at what angle they must cross the greater and the lesser waves of snow in order to arrive at their destination, and they never fail. It often happens that the *true* permanent sastruga has been obliterated by another produced by temporary winds, but the traveler is not deceived thereby; his practiced eye detects the change, he carefully removes the recently drifted snow, and corrects his course by the lower sastruga and by the angle formed by the two.

It will be noticed that in the foregoing passage a single snow ridge of the character mentioned is referred to as a *sastruga*, which is the German transliteration of the Russian singular *zastruga*. The same singular occurs in the following passage from another work:[2]

Noch muss ich hier eine Notiz über die Sastrugi machen, die erhabenen Rippen oder Wellen, die sich auf dem Schnee der Tundra oder des Jenissei bei Stürmen bilden und von den Bewohnern zur Orientirung benutzt werden, indem die Richtung der Sastrugi genau mit der Richtung des letztvorhergegangenen stärkern Windes übereinstimmt. Der nordische Schlittenführer fühlt mit dem Fuss, wenn er wegen Schnees, Nebels oder Dunkelheit keine Fernsicht hat, die Richtung der Sastruga heraus, und weiss dann, in welchem Winkel zur Sastruga er sein Gefährt lenken muss, nachdem er sich zu Anfang der Reise wohl über die Richtung der ältern und neuern Sastrugi unterrichtet hat. Die ältern erkennt er an ihrer grössern Härte und daran, dass ihnen der Kopf fehlt. Die frische Sastruga bildet nämlich einen 1 bis 2 Klafter langen Rücken, der nach dem Winde zu oben scharf ist, mit einer vorspringenden Spitze (der Kopf, der allmählich vom Winde wieder abgetragen wird) und nach der entgegengesetzten Seite (der Schwanz) sich abflacht und verbreitert. Im Kleinen kann man die Sastrugi vortrefflich auf dem Schnee der Newa, nach einem starken Winde, beobachten.

The word *zastruga* has a number of meanings in Russian. It is applied to rough splinters due to planing wood against the grain; to the end of a stick tapered with a spoke-shave or similar tool; to the overhanging bank of a stream, scoured beneath by the current; to a small bay or inlet; also sometimes metaphorically to mental perturbation or anxiety. Whether it is actually applied in Russian to one of the snow ridges which are known collectively as *zastrugi* is not clear from the dictionaries accessible to the present writer. Dal's Dictionary of the Modern Great Russian Language (3d ed., 1903) assigns this meaning only to the plural, which is thus defined:

Zastrúgi or *zástrugi*. Jagged, wavy ridges thrown up by water on a sandy bottom; also, wind-swept snow drifts, wavy at the top, steep and rumpled on the windward side, and gently sloping to leeward.

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[1] **[Engelhardt, L. von].** "Narrative of an expedition to the polar sea in the years 1820, 1821, 1822, & 1823, commanded by Lieutenant, now Admiral, Ferdinand von Wrangel," edited by Maj. Edward Sabine, London, 1840, p. 146-147.

[2] **Schmidt, Friedrich.** "Wissenschaftliche Resultate der zur Aufsuchung eines angekündigten Mammuthcadavers von der Kaiserlichen Akademie der Wissenschaften an den unteren Jenissei ausgesandten Expedition." (Mém. Acad. imp. sci. St. Pétersbourg. 7 sér., t. 18, no. 1, p. 72. Saint-Pétersbourg, 1872.)

SECTION VII.—WEATHER AND DATA FOR THE MONTH.

THE WEATHER OF THE MONTH.

By P. C. DAY, Climatologist and Chief of Division.

Pressure.—The distribution of the mean atmospheric pressure over the United States and Canada, and the prevailing direction of the winds, are graphically shown on Chart VII, while the average values for the month at the several stations, with the departures from the normal, are shown in Tables I and III.

The atmospheric pressure for the month as a whole was above the normal over the Dakotas, northern Minnesota, nearly all sections to eastward of the Mississippi River, and over the extreme southern sections to the westward of that river as well as in the eastern Canadian Provinces, the greatest plus departures appearing in northern New England and the Canadian Maritime Provinces. Over all other portions of the country the means for the month were below the normal, with especially marked departures in the far Northwest, and portions of Nevada and California.

The month opened with low pressure prevailing quite generally throughout the country, except along the Canadian border east of the Rocky Mountains. The well-defined low area that crossed the country during the first decade was followed by rather marked and extensive high pressure, which covered most districts, except the States west of the Rocky Mountains, where the pressure was below the normal. Relatively low pressure again overspread the greater part of the country during the early part of the second decade, which, in turn, was followed by another rather extensive high, which obtained in most sections the latter part of this period, except over the Pacific Slope and extreme southwest, where low pressures predominated. A series of low-pressure areas crossed the country during the third decade, causing unsettled weather conditions until near the end of the month, which closed with generally high pressure over all sections except the New England, Gulf, and Pacific States.

The distribution of the prevailing high and low pressure areas was generally favorable for northerly and northwesterly winds along the seaboard of the New England and middle Atlantic States, northerly and northeasterly winds over the south Atlantic States, including the Florida Peninsula, and for southeasterly winds in the Mississippi Valley, and the Gulf, and Pacific Coast States.

Temperature.—The warm wave that had overspread much of the country during the last day or two of January continued into February, with somewhat higher temperatures in eastern districts but with cooler weather in the Plains region. Only moderate changes in temperatures occurred during the following week or more over the central and western districts, but in the North Atlantic States the changes were quite pronounced, especially during the 1st and 2d and again on the 5th and 6th.

For the first decade as a whole the temperatures were very generally above the normal in all central and northern districts, but over the southern States the period was only moderately warm and in portions of the south Atlantic and east Gulf States and in the far Southwest the averages were somewhat below the normal.

During the middle decade of the month temperatures continued moderately high in most districts and they were unseasonably high in some eastern districts about the 13th and 14th. The decade as a whole, like the preceding, continued warm over all central and northern districts; and like the first decade it was cool over the Southeast and the far Southwest. In the central valleys the period was one of unusual warmth, the averages ranging from 10° to nearly 15° above the normal.

At the beginning of the third decade the temperature was high in practically all portions of the country and during the following few days it continued to rise in the eastern districts, the maximum temperatures about the 23d and 24th being within a few degrees of the highest ever recorded in February at points from the lower Lake region eastward.

During the last few days of the month there was a very general tendency to lower temperatures over most districts, especially in the northeastern States, but elsewhere the daily changes were slight and the month closed with moderately cool weather prevailing over all portions of the country.

The month as a whole may be classed as one of unusual warmth over all northern districts, and especially so in the Upper Lake region and in the Missouri and upper Mississippi valleys, where the positive departures ranged from 8° to 10°. In limited portions of the southeastern States and locally in the far Southwest the averages for the month were slightly less than the normal.

The extremes were within the limits of previous years, although the maximum temperatures over some of the eastern districts on several dates were near the highest previously recorded in February.

Minimum temperatures did not closely approach the low records of previous years, and there were extensive areas in Texas and other Gulf States, as well as on the Pacific coast, that were free from frost during the entire month. Considerable areas in New York and New England had minimum temperatures below zero, the lowest being −14° at Greenville, Me. This record was several degrees below any reported from the northwestern States, where the temperatures are usually considerably lower than in New England.

Precipitation.—The storm referred to in the January issue as central in the Mississippi Valley gradually overspread the districts to the eastward during the following few days, accompanied by heavy rains in the Ohio Valley and portions of the Gulf States, and heavy snow and sleet in portions of the upper Mississippi Valley, Lake region, and New England. During the prevalence of this storm over the eastern districts a severe storm had approached the Pacific coast and heavy rains occurred in portions of California and Oregon and more or less snow in the mountains of those States.

The heavy rains with melting snow over the Ohio watershed caused decided rises in the rivers of that dis-

trict and the main stream was at flood stages for several days from Pittsburgh to Cairo.

The Pacific coast storm lost much of its intensity after passing inland but apparently reestablished its identity to the eastward of the Rocky Mountains, and by the morning of the 4th was central in the lower Missouri Valley, whence it moved during the following few days to the Lake region and St. Lawrence Valley. Some heavy rains occurred from this storm in portions of the Gulf States and moderate rains or snows were very general from the Great Plains eastward.

Generally fair weather prevailed over much of the country after the passage of the above-mentioned storm until about the 12th, when a disturbance appeared over the southern Rocky Mountain region and moved to the Great Lakes during the following two or three days. Considerable snow occurred in the northern and western areas of the storm track and moderately heavy rains fell over most eastern and southern districts.

But little precipitation occurred over the central and western districts from the 15th to the 20th. About the latter date, however, unsettled weather developed in the far Southwest, and by the morning of the 21st low pressure was general from the middle Mississippi Valley westward, and light rains or snows were falling over most of the region. This storm gradually overspread the districts to eastward of the Mississippi during the following few days, and local heavy rains fell at points in the lower Mississippi Valley, Gulf States, and in the Atlantic coast districts. Heavy, wet snows occurred in portions of Kansas, Iowa, and surrounding States, greatly damaging telegraph and telephone lines and interfering with railroad traffic.

After the passage of this storm, fair weather was general during the balance of the month in most districts until near the end, when light snows occurred over much of the mountain and plateau regions, extending into the middle Plains, with light rains over large portions of the Gulf States.

The precipitation for the month was deficient over much of the central and southern portions of the country from the Mississippi Valley eastward, and in excess of the average over similar districts to the westward of that river. Marked deficiencies occurred in the lower Ohio Valley, portions of the Gulf and South Atlantic States, and the far Northwest, while excesses were equally pronounced in some of the Northeastern States, the middle portions of the Great Plains region, California, and portions of the far Southwest.

In general the precipitation was sufficient for present needs, and the soil being largely free from frost offered unusual opportunity for the moisture to penetrate well into the subsoil.

Snowfall.—In general the snowfall during the month was much less than the average, this being especially true for the districts to eastward of the Mississippi and in the northern mountain regions of the West. Some heavy falls occurred in the Plains region from Kansas and Iowa northward, and in portions of the southern Rocky Mountain districts and the high ranges of California.

In the mountain districts of Montana, Idaho, Washington, Oregon, and portions of Utah and Wyoming the total fall for the winter has so far been much less than the average, and the outlook is for a decided shortage of irrigation water for the late summer. On the other hand the fall in California, and portions of Nevada, Arizona, New Mexico, and southern Utah has been in excess of the normal, and much of it is well packed and in condition to justify a forecast for an abundant supply of water during the coming crop-growing season.

At the end of the month the snow had largely disappeared and only small amounts remained on the ground where it was covered at all, save in portions of the upper Lake region, in parts of the Dakotas, Nebraska, Iowa, and Minnesota, and in the higher elevations of the mountain districts of the West.

GENERAL SUMMARY.

The month as a whole presented unusual opportunities for the successful prosecution of most outdoor pursuits. Warm and fair weather prevailed over large portions of the country for lengthy periods, and the general absence of frost in the soil permitted an unusual amount of plowing and other preparation of the soil for spring planting. In the winter-grain growing regions the snow had largely disappeared early in the month leaving the soil well saturated and the growing crop in good condition save over some of the more eastern districts where alternate freezing and thawing caused some injury to both wheat and grass.

In the cotton-growing States the favorable weather permitted excellent progress with farming operations and the season was well advanced, except in portions of the middle Gulf States where the ground was generally too wet. Winter crops were reported to have made good growth and some early truck planting has been accomplished. The outlook for fruit appeared excellent at the end of the month and peaches were in blossom over the southern districts.

In the western districts the weather was unusually favorable for the live-stock interests, and cattle were reported to be in excellent condition.

In the northern mountain districts the streams were unusually low, and the absence of any large amount of snow in the mountains indicated that their volume would be less than usual during the coming summer. On the other hand water was plentiful in the southern mountain districts and their streams will probably carry an abundance of water.

Maximum wind velocities, February, 1915.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
		Mi./hr.		NorthHead, Wash.—		*Mi./hr.*	
Block Island, R. I...	2	56	ne.	Continued........	6	54	se.
Do............	26	59	nw.	Do............	8	75	se.
Do............	27	58	w.	Do............	9	64	se.
Buffalo, N. Y.......	6	50	sw.	Pensacola, Fla......	5	52	s
Do............	7	50	sw.	Pt. Reyes Light, Cal.	1	91	s.
Cheyenne, Wyo.....	3	52	w.	Do............	2	95	sw.
Do............	4	50	nw.	Do............	3	65	nw.
Do............	5	50	nw.	Do............	7	88	s.
El Paso, Tex.......	21	52	sw.	Do............	8	88	s.
Green Bay, Wis.....	1	51	ne.	Do............	15	68	s.
Hatteras, N. C......	18	51	n.	Do............	16	64	s.
Lincoln, Nebr.......	5	52	nw.	Do............	20	57	nw.
Marquette, Mich....	10	50	sw.	Do............	21	56	s.
Modena, Utah.......	2	72	sw.	Do............	22	58	s.
Mt. Tamalpais, Cal..	2	68	sw.	Do............	24	73	nw.
Do............	7	56	se.	Do............	25	65	nw.
Do............	8	64	sw.	Do............	26	50	nw.
Do............	16	50	sw.	Do............	28	60	nw.
Do............	27	52	nw.	Reno, Nev..........	7	50	s.
Do............	28	58	nw.	Sacramento, Cal.....	8	57	se.
New York, N. Y....	5	52	se.	San Francisco, Cal...	2	51	sw.
Do............	6	60	se.	Sioux City, Iowa....	5	55	nw.
Do............	24	50	se.	Do............	14	53	nw.
Do............	26	57	nw.	Tatoosh Island, Wash	1	54	s.
Do............	27	56	nw.	Do............	5	58	s.
North Head, Wash..	3	62	se.	Do............	14	50	s.
Do............	4	54	se.	Wichita, Kans......	4	50	sw.
Do............	5	60	se.				

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Average accumulated departures for February, 1915.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	°F.	°F.	°F.	In.	In.	In.			P. ct.	P. ct.
New England......	30.0	+ 4.2	+ 8.7	3.62	+0.30	+2.40	6.1	+0.8	76	+ 1
Middle Atlantic....	37.2	+ 4.5	+ 7.6	3.76	+0.50	+2.40	5.8	+0.3	73	− 1
South Atlantic.....	48.1	+ 1.4	+ 2.7	2.39	−1.70	0.00	5.0	−0.3	71	− 5
Florida Peninsula..	64.8	− 2.1	− 2.1	3.44	+0.90	+3.60	5.2	+0.9	76	− 4
East Gulf..........	50.6	− 0.3	− 1.0	4.01	−0.80	+1.30	5.2	−0.4	70	− 6
West Gulf..........	52.8	+ 3.1	+ 3.0	2.47	−0.30	−0.60	5.1	−0.5	71	− 3
Ohio Valley and Tennessee........	40.4	+ 4.7	+ 4.2	1.88	−1.70	−0.90	6.7	−0.5	72	− 2
Lower Lakes.......	29.7	+ 5.0	+ 5.3	2.10	−0.40	+0.20	7.0	+0.2	80	0
Upper Lakes.......	26.7	+ 7.5	+ 7.5	2.09	+0.40	+0.20	7.0	+0.7	83	+ 1
North Dakota......	18.4	+11.4	+13.6	0.58	0.00	−0.40	6.9	+1.9	86	+ 6
Upper Mississippi Valley............	33.2	+ 8.6	+ 7.9	2.52	+0.80	+1.20	6.8	+1.6	80	+ 3
Missouri Valley.....	31.5	+ 2.5	+ 8.7	2.61	+1.60	+2.20	6.7	+1.5	85	+10
Northern slope.....	27.2	+ 5.7	+ 6.4	0.77	0.00	−0.60	5.6	+0.5	75	+ 4
Middle slope........	38.3	+ 6.0	+ 7.8	2.20	+1.40	+1.50	5.4	+1.0	69	+ 2
Southern slope......	48.4	+ 3.8	+ 2.7	0.96	+0.10	+0.40	3.9	−0.9	56	−12
Southern Plateau...	42.8	− 2.0	− 5.1	0.78	+0.10	+1.00	3.7	+0.1	60	+16
Middle Plateau.....	35.9	+ 2.9	+ 1.3	1.55	+0.40	+0.20	6.4	+1.3	72	+ 8
Northern Plateau...	39.0	+ 6.9	+ 5.4	1.36	−0.10	−0.90	7.4	+1.2	72	− 3
North Pacific.......	44.1	+ 3.4	+ 4.7	3.84	−1.70	−3.00	7.8	+0.7	82	+ 1
Middle Pacific......	49.3	+ 0.3	+ 0.6	8.14	+3.80	+6.50	7.2	+1.6	85	+ 9
South Pacific.......	53.7	+ 1.1	+ 2.7	5.42	+3.00	+5.30	6.1	+1.8	77	+ 8

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau, the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data, as indicated by the several headings

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Summary of temperature and precipitation, by sections, February, 1915.

Section.	Temperature (°F.). Section average.	Departure from the normal.	Monthly extremes. Station.	Highest.	Date.	Station.	Lowest.	Date.	Precipitation (in inches and hundredths). Section average.	Departure from the normal.	Greatest monthly. Station.	Amount.	Least monthly. Station.	Amount.
Alabama	48.6	+ 1.7	Wetumpka	74	12	Hamilton	17	9	4.63	−0.90	Citronelle	9.21	Camp Hill	1.65
Arizona	45.7	− 1.0	4 stations	80	9†	Alpine	−10	7	1.81	+0.62	Pinal Ranch	5.53	Douglass	0.43
Arkansas	45.9	+ 4.3	Camden	76	21	Dutton	11	8	4.47	+0.97	Helena	6.90	Little Rock	2.52
California	46.6	− 1.9	King City	89	1	Bridgeport	−20	13	10.08	+5.67	Upper Mattole	38.74	Calexico	0.02
Colorado	28.7	+ 3.1	Holly	77	10	Pagosa Springs	−32	5	1.49	+0.22	Savage Basin	7.15	Manassa	0.06
Florida	59.0	− 1.0	Arcadia	86	1	Garniers (near)	25	9	3.85	+0.36	Bradentown	7.34	Wausau	1.14
Georgia	48.6	+ 1.2	2 stations	78	14†	Gainesville	16	9	4.04	−1.25	Toccoa	6.93	Savannah	1.60
Hawaii (January)	67.4	......	Molokai Ranch	88	13	Volcano House	40	20	2.11	....	Honokano	11.22	8 stations	0.00
Idaho	33.9	+ 5.6	Grandview	67	19	Pierson	−19	14	1.87	+0.15	Landore	5.27	2 stations	0.19
Illinois	36.5	+ 9.0	Mascoutah	70	12	Lanark	− 1	9	2.18	−0.13	Nashville	2.98	Dakota	1.04
Indiana	37.1	+ 8.4	Rome	70	22	Notre Dame	6	10	1.58	−1.37	Winona Lake	3.04	Marengo	0.40
Iowa	29.1	+ 8.6	Keokuk	62	11	2 stations	− 8	8	2.94	+1.79	Rockwell City	5.39	Fairfield	0.43
Kansas	38.0	+ 7.4	2 stations	81	10	2 stations	2	2	2.72	+1.58	Fall River	5.78	St. Francis	0.50
Kentucky	41.9	+ 6.5	Beattyville	75	22	Eubank	13	9†	1.74	−2.00	Shelbyville	2.83	Farmers	0.84
Louisiana	53.2	+ 0.8	Lake Charles	79	16	2 stations	23	7	6.01	+1.30	Simmesport	11.01	Florence	2.03
Maryland & Delaware	37.4	+ 5.5	2 stations	72	15†	Deer Park, Md	−15	10	4.36	+1.09	Darlington, Md	7.12	Grantsville, Md	1.58
Michigan	26.8	+ 8.3	St. Joseph	63	21	Humboldt	−23	28	2.05	+0.15	Vassar	5.03	Adrian	0.22
Minnesota	21.6	+10.6	2 stations	46	18†	Winton	−22	26	1.68	+1.08	Albert Lea	5.06	Grand Marais	0.15
Mississippi	49.5	+ 2.2	Hattiesburg	77	12	2 stations	22	7†	6.20	+1.03	Hattiesburg	10.20	Meridian	3.27
Missouri	39.4	+ 8.0	Belle	72	12	2 stations	7	8	3.18	+0.81	Warsaw	4.94	Tarkio	0.85
Montana	27.1	+ 6.4	Como	66	2	Bowen	−23	5	0.48	−0.23	Heron	2.57	2 stations	0.00
Nebraska	28.4	+ 4.0	Hayes Center	69	10	Gordon	−17	15	2.02	+1.27	Du Bois	5.20	Elsie	0.13
Nevada	36.5	+ 3.6	Golconda	70	17	2 stations	− 5	6†	1.38	+0.19	Marlette Lake	8.39	Tecoma	0.14
New England	28.2	+ 5.3	Orono, Me	64	6	Patten, Me	−32	1	4.14	+0.79	Amherst, Mass	7.02	Houlton, Me	1.14
New Jersey	35.7	+ 5.4	Indian Mills	75	15	Culvers Lake	2	10	5.37	+1.56	Elizabeth	7.28	Pleasantville	2.97
New Mexico	36.2	− 0.7	Carlsbad	84	5	Dulce	−26	6	1.06	+0.18	Anchor Mine	3.92	Magdalena	0.10
New York	27.5	+ 6.1	Setauket	62	24	Old Forge	−26	10	3.60	+0.84	Mount Hope	7.19	Lauterbrunnen	0.44
North Carolina	44.9	+ 3.6	2 stations	80	1†	Banners Elk	9	10	3.89	−0.65	Highlands	12.11	Manteo	1.06
North Dakota	17.3	+ 9.8	New Rockford	50	28	2 stations	−20	2	0.60	+0.10	Lisbon	4.20	2 stations	0.00
Ohio	35.2	+ 7.8	Ironton	70	22	Garrettsville	− 9	9	1.96	−0.73	Montpelier	3.90	Bellefontaine	0.77
Oklahoma	44.5	+ 5.7	Hooker	83	10	Hurley	4	23	3.65	+2.66	Stillwater	6.61	Goodwell	1.25
Oregon	39.7	+ 3.4	Cliff (2)	68	5†	Crescent	3	14	3.50	−0.73	Happy Home	14.94	Umatilla	0.66
Pennsylvania	33.3	+ 6.1	Punxsutawney	73	23	West Bingham	− 9	10	3.90	+0.66	Shamont	6.95	Lawrenceville	1.85
Porto Rico	73.5	+ 0.2	San Sebastian	94	16	2 stations	48	24†	3.75	+1.15	Rio Grande	22.64	3 stations	0.00
South Carolina	48.6	+ 1.8	Bowman	80	14	2 stations	20	9	3.15	−1.31	Landrum	7.38	Yemassee	1.69
South Dakota	23.3	+ 7.1	Hermosa	62	10	2 stations	−14	2†	1.83	+1.52	Marion	5.46	Sorum	0.14
Tennessee	43.6	+ 4.4	Johnson City	73	22	Erasmus	8	9	3.20	−1.37	Bolivar	6.05	Sewanee	0.59
Texas	53.5	+ 3.8	Eagle Pass	86	14	Lieb (near)	5	1	1.89	−0.04	San Augustine	6.74	3 stations	0.00
Utah	32.1	+ 1.4	St. George	68	9	Scofield	−20	6†	2.04	+0.83	New Harmony	5.92	Hanksville	0.36
Virginia	40.6	+ 4.7	Diamond Springs	76	1	Burkes Garden	9	10	3.41	−0.07	Ashland	5.17	Cape Henry	1.29
Washington	38.9	+ 4.5	Mottenger	66	23	Bumping Lake	− 2	14	3.08	−0.80	Lake Cushman	17.57	2 stations	0.61
West Virginia	38.4	+ 6.9	2 stations	72	23	2 stations	− 2	10	3.07	−0.16	Davis	6.33	Upper Tract	0.90
Wisconsin	25.6	+ 9.9	Spooner (2)	52	20	Winter	−19	9	2.24	+1.18	Stevens Point	4.38	Solon Springs	0.35
Wyoming	26.8	+ 5.7	Wheatland	74	10	Moran	−29	5	0.71	−0.08	Kirtley	2.40	3 stations	0.00

† Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

Table I gives the data ordinarily needed for climatological studies for about 158 Weather Bureau stations making simultaneous observations at 8 a. m. and 8 p. m., seventy-fifth meridian time daily, and for about 41 others making only one observation. The altitudes of the instruments above ground are also given.

Table II gives a record of precipitation, the intensity of which at some period of the storm's continuance equaled or exceeded the following rates:

Duration (minutes)	5	10	15	20	25	30	35	40	45	50	60
Rates per hour (inches)	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.87	0.84	0.80

It is impracticable to make this table sufficiently wide to accommodate on one line the record of accumulated falls that continue at an excessive rate for several hours. In this case *the record is broken at the end of each 50 minutes*, the accumulated amounts being recorded on successive lines until the excessive rate ends.

In cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred, the greatest precipitation of any single storm has been given, also the greatest hourly fall during that storm.

Table III gives, for about 30 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values, except in the case of snowfall.

Chart I.—Hydrographs for several of the principal rivers of the United States.

Chart II.—Tracks of centers of high areas; and

Chart III.—Tracks of centers of low areas. The roman numerals show the chronological order of the centers. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the observations at 8 a. m. and 8 p. m., 75th meridian time. Within each circle is also given (Chart II) the last three figures of the highest barometric reading and (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sea level and standard gravity.

Chart IV.—Temperature departures. This chart presents the departures of the monthly mean temperatures from the monthly normals. The normals used in computing the departures were computed for a period of 33 years (1873 to 1905) and are published in Weather Bureau Bulletin "R," Washington, 1908. Stations whose records were too short to justify the preparation of normals in 1908, have been provided with normals as adequate records became available and all have been reduced to the 33-year interval 1878–1905. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximate equal departures of like sign. This chart of monthly temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July, 1909.

Chart V.—Total precipitation. The scale of shades showing the depth is given on the chart. Where the monthly amounts are too small to justify shading, and over sections of the country where stations are too widely separated or the topography is too diversified to warrant reasonable accuracy in shading, the actual depths are given for a limited number of representative stations. Amounts less than 0.005 inch are indicated by the letter T, and no precipitation by 0.

Chart VI.—Percentage of clear sky between sunrise and sunset. The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the night time.

Chart VII.—Isobars and isotherms at sea level and prevailing wind directions. The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow on pages 13–16 of the REVIEW for January, 1902. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of the 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observations, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in the Annual Report of the Chief of the Weather Bureau, 1900–1901, volume 2, Table 27, pages 140–164.

The isotherms on the sea-level plane have been constructed by means of the data summarized in chapter 8 of volume 2 of the annual report just mentioned. The correction t_0-t, or temperature on the sea-level plane minus the station temperature as given by Table 48 of that report, is added to the observed surface temperature to obtain the adopted sea-level temperature.

The prevailing wind directions are determined from hourly observations at the great majority of the stations; a few stations having no self-recording wind direction apparatus determine the prevailing direction from the daily or twice-daily observations only.

Chart VIII.—Total snowfall. This is based on the reports from regular and cooperative observers and shows the depth in inches and tenths of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures are also given.

Chart VIII is published only when the general snow cover is sufficiently extensive to justify its preparation

TABLE I.—*Climatological data for United States Weather Bureau stations, February, 1915.*

Districts and stations.	Elevation of instruments. Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Pressure in inches. Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air, in degrees Fahrenheit. Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Precipitation, inches. Total.	Departure from normal.	Days with 0.01 or more.	Wind. Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
New England.							**30.0**	**+ 4.2**										**76**	**3.62**	**+ 0.3**										**6.1**		
Eastport	76	67	85	30.01	30.10	+0.12	27.6	+ 6.2	47	25	34	− 6	2	21	31	26	23	80	2.57	− 1.0	12	8,418	nw.	40	ne.	8	6	7	15	7.0	10.3	T.
Greenville	1,070	6	....	28.88	30.10	......	20.4	......	45	22	30	−15	4	10	41	....	....	....	4.36	......	10	......	......	....	......	....	....	....	....	....	15.0	....
Portland, Me	103	82	117	29.99	30.12	+ .10	28.4	+ 4.6	47	6	36	− 1	2	21	30	25	19	68	3.72	+ 0.1	11	6,401	n.	30	se.	25	9	4	15	6.0	10.5	....
Concord	288	70	79	29.79	30.12	+ .08	27.8	+ 4.2	50	23	37	− 2	5	18	42	....	....	....	2.89	− 0.4	8	3,771	nw.	23	nw.	27	11	6	11	5.2	4.0	0.2
Burlington	404	11	48	29.66	30.13	+ .10	23.6	+ 5.7	48	23	32	− 6	4	15	29	....	....	....	3.28	+ 1.9	12	7,392	n.	48	s.	11	7	5	16	6.7	18.2	6.6
Northfield	876	12	60	29.14	30.13	+ .09	22.2	+ 5.0	48	23	33	− 7	10	12	45	19	16	82	3.32	+ 1.1	9	4,720	s.	29	se.	11	7	3	18	6.9	11.6	2.0
Boston	125	115	188	29.96	30.10	+ .06	33.2	+ 4.2	61	24	40	10	2	26	25	30	24	71	3.47	0.0	12	7,475	nw.	32	ne.	2	10	8	10	5.1	5.1	....
Nantucket	12	14	90	30.06	30.07	+ .03	35.0	+ 2.4	49	15	40	20	27	30	18	33	30	84	3.32	+ 0.2	9	13,259	ne.	48	ne.	4	5	7	16	7.5	5.1	....
Block Island	26	11	46	30.05	30.08	+ .02	33.2	+ 2.0	52	24	38	16	10	28	19	31	29	83	3.38	− 0.9	9	13,198	nw.	59	nw.	26	11	1	16	6.1	T.	....
Narragansett Pier	.....	9	....	......	......	......	31.4	+ 3.1	47	24	38	9	11	25	31	....	....	....	4.00	......	8	......	sw.	....	......	....	14	3	11	....	1.5	T.
Providence	160	215	251	29.92	30.10	+ .05	32.0	+ 3.0	54	25	39	10	3	25	27	29	24	76	3.30	− 1.1	11	9,977	nw.	49	nw.	26	12	6	10	5.2	0.8	....
Hartford	159	122	140	29.93	30.11	+ .05	32.0	+ 4.8	60	24	40	10	2	24	23	29	24	74	4.30	+ 0.8	11	5,097	nw.	26	s.	6	9	5	14	5.9	3.0	....
New Haven	106	117	155	29.99	30.11	+ .04	33.8	+ 5.5	56	24	41	12	10	27	25	29	23	68	6.31	+ 2.6	10	6,839	n.	34	nw.	27	10	5	13	5.6	2.7	....
Middle Atlantic States.							**37.2**	**+ 4.5**										**73**	**3.76**	**+ 0.5**										**5.8**		
Albany	97	102	115	30.02	30.13	+ .06	28.6	+ 5.0	54	24	36	5	2	22	26	26	23	81	3.79	+ 1.3	11	6,149	s.	31	s.	5	11	1	16	6.0	4.3	0.5
Binghamton	871	10	69	29.15	30.11	+ .03	31.0	+ 6.3	59	23	38	12	9	24	31	....	....	....	2.63	+ 0.7	13	4,261	nw.	24	ne.	2	5	5	18	7.0	1.7	0.3
New York	314	414	454	29.76	30.11	+ .03	35.2	+ 4.5	60	15	42	13	10	29	21	31	24	66	5.03	+ 1.3	9	13,358	nw.	60	se.	6	9	7	12	5.9	2.5	....
Harrisburg	374	94	104	29.73	30.15	+ .06	34.7	+ 4.8	59	23	41	14	10	28	25	31	25	71	4.26	+ 1.6	7	5,242	nw.	28	nw.	27	8	4	16	6.5	T.	....
Philadelphia	117	123	190	30.01	30.14	+ .04	38.8	+ 6.0	67	15	46	16	10	32	24	34	30	76	5.55	+ 2.2	10	8,243	nw.	42	ne.	2	8	6	14	5.9	1.8	....
Reading	325	81	98	29.77	30.14	......	35.8	......	60	23	43	14	10	29	28	31	26	70	5.55	+ 2.0	7	5,644	nw.	34	e.	2	6	3	19	6.9	T.	....
Scranton	805	111	119	29.24	30.13	+ .05	33.2	+ 6.3	62	23	41	11	10	26	31	30	26	76	2.70	0.0	8	4,986	s.	36	ne.	2	5	8	15	7.1	0.1	....
Atlantic City	52	37	48	30.07	30.13	+ .02	36.5	+ 3.5	55	12	42	15	10	31	19	33	29	78	3.69	+ 0.4	8	6,182	nw.	29	e.	2	10	6	12	5.4	2.2	....
Cape May	18	13	49	30.13	30.15	+ .04	37.5	+ 3.4	54	12	43	18	10	32	16	....	....	....	3.71	+ 0.4	8	6,909	nw.	34	nw.	27	11	5	12	5.5	5.3	....
Sandy Hook	22	10	57	30.10	30.12	......	35.2	......	58	15	40	16	10	30	19	33	31	86	4.51	......	9	11,935	nw.	48	nw.	27	9	6	13	5.9	1.4	....
Trenton	190	159	183	29.90	30.11	......	36.0	......	67	15	43	14	10	29	26	32	26	72	4.40	+ 1.2	10	8,822	nw.	42	nw.	27	9	7	12	5.9	3.1	....
Baltimore	123	100	113	30.01	30.15	+ .04	38.4	+ 3.8	59	23	45	17	10	32	24	34	28	69	4.75	+ 1.2	7	6,617	n.	36	n.	18	9	5	14	6.1	1.5	....
Washington	112	62	85	30.01	30.14	+ .03	38.8	+ 4.3	68	23	47	18	10	31	33	33	27	69	3.60	+ 0.2	8	5,363	nw.	35	nw.	26	10	4	14	5.9	3.0	....
Lynchburg	681	153	188	29.36	30.13	+ .02	42.2	+ 4.0	71	22	52	20	10	33	39	36	30	70	2.88	− 0.6	7	5,008	nw.	28	nw.	26	13	6	9	5.3	.....	....
Norfolk	91	170	205	30.03	30.14	+ .03	45.4	+ 3.6	73	1	53	26	10	38	28	39	34	70	1.71	− 2.0	6	9,744	n.	42	nw.	24	11	9	8	4.6	T.	....
Richmond	144	11	52	29.98	30.15	+ .04	43.7	+ 3.8	70	15	53	23	10	34	39	37	32	74	3.92	+ 0.8	10	5,556	ne.	27	nw.	27	16	3	9	4.2	1.6	....
Wytheville	2,293	40	47	27.69	30.14	+ .02	38.5	+ 3.4	64	13	48	16	10	29	37	33	28	74	2.02	− 2.1	8	4,190	w.	26	w.	6	15	7	6	4.2	T.	....
South Atlantic States.							**48.1**	**+ 1.4**										**71**	**2.39**	**− 1.7**										**5.0**		
Asheville	2,255	70	84	27.73	30.16	+ .03	40.2	+ 2.7	62	22	49	18	10	31	35	34	29	72	2.78	− 1.9	8	7,400	nw.	32	se.	1	11	5	12	5.2	0.1	....
Charlotte	773	68	76	29.28	30.14	+ .02	45.7	+ 1.6	67	14	55	22	9	36	30	39	33	67	2.89	− 1.5	7	5,219	ne.	29	sw.	6	11	8	9	5.4	.....	....
Hatteras	11	12	50	30.11	30.12	+ .01	47.8	+ 1.2	70	15	54	34	11	42	20	43	40	80	1.98	− 2.5	7	11,187	n.	51	n.	18	10	9	9	5.4	.....	....
Manteo	12	4	46	......	......	......	46.2	......	77	23	57	21	11	36	....	....	....	....	1.06	− 3.2	4	......	ne.	....	......	....	13	6	9	....	.....	....
Raleigh	376	103	110	29.72	30.14	+ .03	46.1	+ 2.8	70	15	56	25	10	36	31	40	33	66	3.24	− 1.1	8	6,015	ne.	36	w.	6	11	8	9	4.7	.....	....
Wilmington	78	81	91	30.05	30.14	+ .02	49.6	+ 1.9	72	13	59	27	20	40	29	43	38	73	2.97	− 0.4	6	5,540	n.	28	s.	1	12	10	6	4.1	.....	....
Charleston	48	11	92	30.08	30.13	+ .01	51.5	− 0.2	73	15	59	33	9	44	25	45	40	73	2.53	− 0.9	8	7,245	ne.	31	ne.	17	11	9	8	4.7	.....	....
Columbia, S. C	351	41	57	29.76	30.15	+ .04	49.2	+ 1.4	72	14	59	27	9	40	31	41	34	63	2.25	− 2.3	7	5,266	ne.	32	sw.	2	14	3	11	4.7	.....	....
Augusta	180	89	97	29.95	30.15	+ .03	49.7	+ 0.7	74	14	59	27	10	40	32	43	38	72	2.59	− 1.8	7	4,753	w.	32	se.	5	10	7	11	5.1	.....	....
Savannah	65	150	194	30.06	30.13	+ .01	53.0	+ 0.5	72	15	61	34	10	45	23	46	41	72	1.60	− 1.7	8	8,867	ne.	39	s.	1	12	8	8	4.8	.....	....
Jacksonville[1]	43	96	129	30.07	30.12	.00	.....	......	....	....	....	....	....	....	....	....	....	....	2.44	......	....	......	ne.	....	......	....	8	7	13	5.6	.....	....
Florida Peninsula.							**64.8**	**− 2.1**										**76**	**3.44**	**+ 0.9**										**5.2**		
Key West	22	10	64	30.03	30.05	− .02	68.4	− 2.4	81	28	73	53	9	63	16	62	59	77	2.59	+ 1.0	6	8,986	n.	38	n.	2	14	10	4	3.9	.....	....
Miami	25	71	79	30.04	30.07	......	65.6	− 3.2	82	28	72	43	8	60	24	59	56	74	3.01	+ 0.3	7	8,106	nw.	29	ne.	11	5	9	14	6.6	.....	....
Sand Key	23	39	72	30.01	30.04	− .03	68.2	......	77	1	72	56	9	65	13	64	61	77	1.57	......	6	13,757	ne.	48	nw.	2	12	8	8	4.2	.....	....
Tampa	35	79	96	30.06	30.10	.00	60.3	− .06	79	1	68	41	9	52	25	53	49	75	4.71	+ 1.4	9	5,473	ne.	27	e.	27	10	4	14	6.0	.....	....
Titusville	44	6	....	......	......	......	.....	......	....	....	....	....	....	....	....	....	....	....	......	......	....	......	......	....	......	....	....	....	....	....	.....	....
East Gulf States.							**50.6**	**− 0.3**										**70**	**4.01**	**− 0.8**										**5.2**		
Atlanta	1,174	190	216	28.88	30.14	+ .02	45.8	+ 0.6	66	22	54	24	9	38	25	40	34	69	4.50	− 0.2	7	8,817	nw.	32	nw.	25	10	5	13	5.4	T.	....
Macon	370	78	87	29.73	30.14	+ .02	49.2	+ 0.3	71	14	58	26	10	40	33	43	37	69	3.58	− 1.0	7	4,775	nw.	26	se.	5	10	5	13	5.5	.....	....
Thomasville	273	8	57	29.82	30.12	.00	52.8	− 2.2	72	14	63	28	10	43	32	46	42	78	3.44	− 1.0	9	4,080	nw.	26	s.	1	12	5	11	5.0	.....	....
Pensacola	56	140	182	30.06	30.12	+ .01	53.4	− 2.1	67	14	60	36	7	47	24	48	43	74	3.30	− 1.2	8	9,928	se.	52	s.	5	10	6	12	5.2	.....	....
Anniston	741	9	57	29.34	30.16	+ .04	47.1	+ 1.3	66	13	56	23	9	38	32	....	....	....	5.99	+ 1.3	7	5,027	se.	29	se.	4	10	9	9	5.1	.....	....
Birmingham	700	11	48	29.36	30.15	+ .03	47.8	− 0.5	68	13	56	26	9	39	31	40	32	61	1.95	− 2.8	7	5,989	s.	40	se.	5	9	10	9	5.2	T.	....
Mobile	57	125	161	30.05	30.11	.00	53.3	+ 0.1	70	5	61	36	7	46	26	47	41	71	4.91	− 0.4	10	7,463	nw.	41	se.	5	11	7	10	4.6	.....	....
Montgomery	223	100	112	29.88	30.14	+ .02	50.6	− 0.7	69	14	59	31	9	42	27	43	36	64	5.47	0.0	8	5,117	e.	26	w.	23	9	9	10	5.4	.....	....
Meridian	375	85	93	29.71	30.12	+ .01	48.8	− 0.3	69	13	58	28	9	40	33	44	38	73	3.27	− 1.6	8	4,333	e.	30	e.	21	10	4	14	5.6	.....	....
Vicksburg	247	65	74	29.84	30.12	+ .02	51.5	+ 0.6	72	12	60	33	3	43	26	44	39	69	3.45	− 1.2	6	5,586	se.	27	se.	4	13	5	10	4.9	.....	....
New Orleans	51	90	121	30.04	30.10	+ .01	56.2	− 0.1	73	12	64	39	10	49	28	50	45	74	4.23	− 0.2	8	6,266	se.	38	se.	4	12	7	9	4.8	.....	....
West Gulf States.							**52.8**	**+ 3.1**										**71**	**2.47**	**− 0.3**										**5.1**		
Shreveport	249	77	93	29.82	30.10	+ .01	51.4	+ 1.4	74	21	60	32	3	43	32	45	39	69	4.15	+ 0.5	9	5,691	se.	25	nw.	4	11	4	13	5.2	.....	....
Bentonville	1,303	11	44	28.63	30.02	− .08	41.8	+ 3.3	65	10	50	21	8	33	33	....	....	....	3.39	+ 0.9	11	5,226	w.	28	sw.	22	10	5	13	5.8	2.6	0.5
Fort Smith	457	79	94	29.56	30.06	− .04	45.6	+ 3.8	69	10	54	28	3	38	30	40	36	74	3.25	+ 0.5	10	7,889	e.	40	sw.	22	8	6	14	6.0	2.1	....
Little Rock	357	139	147	29.71	30.09	− .02	46.4	+ 2.3	67	11	54	29	7	39	27	42	37	74	2.52	− 1.7	9	6,903	e.	34	sw.	13	9	6	13	5.7	T.	....
Brownsville	57	3	40	......	......	......	64.3	......	83	22	74	37	7	55	34	....	....	....	0.04	......	1	......	s.	40	s.	12						
Corpus Christi	20	69	77	30.04	30.06	+ .01	62.0	+ 4.3	77	22	68	43	7	56	27	56	52	77	0.23	− 1.8	5	8,335	se.	42	se.	12	11	9	8	4.8	.....	....
Dallas	512	109	117	29.50	30.06	......	51.5	......	71	10	61	31	2	42	38	....	....	....	2.02	......	7	7,622	se.	39	s.	10	12	6	10	4.9	.....	....
Fort Worth	670	106	114	29.32	30.04	− .03	52.2	+ 4.1	72	10	62	32	2	42	37	45	38	63	2.18	+ 0.9	8	7,864	nw.	36	nw.	22	10	9	9	5.5	.....	....
Galveston	54	106	114	30.03	30.09	+ .02	56.9	+ 1.3	67	21	61	41	7	52	25	52	49	80	2.65	− 0.4	8	8,268	se.	36	n.	27	16	7	5	3.8	.....	....
Houston	138	111	121	29.92	30.07	......	57.8	+ 3.8	74	21	66	40	6	50	28	....	....	....	3.16	......	7	6,311	se.	31	se.	12	15	3	10	4.0	.....	....
Palestine	510	64	72	29.52	30.06	− .02	53.6	+ 2.7	72	11	62	34	2	45	29	47	42	70	2.64	− 0.8	6	3,885	nw.	22	nw.	28	11	9	8	5.2	.....	....
San Antonio	701	109	132	29.32	30.05	.00	58.4	+ 4.0	76	13	69	37	7	48	30	50	42	61	1.81	0.0	6	5,949	sw.	30	n.	4	11	9	8	4.8	.....	....
Taylor	582	55	63	29.47	30.08	+ .02	54.7	+ 3.4	74	13	65	34	2	44	34	....	....	....	1.91	− 0.7	7	6,156	se.	31	n.	10	10	9	9	5.2	.....	....

[1] Station damaged by fire, January 3, 1915.

TABLE I.—*Climatological data for United States Weather Bureau stations, February, 1915*—Continued.

Districts and stations.	Elevation of instruments.			Pressure in inches.			Temperature of the air, in degrees Fahrenheit.									Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Precipitation, inches.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with 0.01 or more.	Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
Ohio Valley and Tennessee.							**40.4**	**+ 4.7**										**72**	**1.88**	**− 1.7**										**6.7**		
Chattanooga	762	189	213	29.33	30.16	+0.03	45.6	+ 1.9	65	22	53	25	9	38	27	38	31	62	4.46	− 0.5	7	6,373	s.	35	se.	4	9	8	11	5.8	2.6	1.3
Knoxville	996	93	100	29.06	30.14	+ .02	43.8	+ 3.0	68	22	52	20	9	35	32	38	32	68	3.37	− 1.5	8	3,567	ne.	32	sw.	5	5	8	15	6.7	0.2	....
Memphis	399	76	97	29.70	30.14	+ .03	46.0	+ 2.7	66	13	53	29	8	39	22	40	34	67	3.31	− 1.0	5	6,483	se.	37	sw.	5	10	5	13	5.6	1.3	....
Nashville	546	168	191	29.54	30.14	+ .02	44.0	+ 2.9	66	14	52	24	9	36	28	38	32	67	1.01	− 3.3	8	7,874	se.	44	se.	5	6	8	14	6.7	T.	T.
Lexington	989	75	102	29.02	30.12	+ .01	39.8	+ 4.2	64	22	47	18	8	32	24	....	....	....	1.12	− 2.1	10	7,870	se.	39	se.	5	5	8	15	6.9	0.2	....
Louisville	525	219	255	29.54	30.13	+ .02	41.8	+ 5.2	65	22	49	20	8	35	24	36	31	69	0.93	− 2.8	6	9,128	s.	48	sw.	5	4	10	14	6.9	T.	....
Evansville	431	72	82	29.63	30.11	.00	41.2	+ 5.4	64	13	47	20	8	35	25	36	31	70	1.24	− 1.8	7	6,160	se.	34	s.	23	6	6	16	6.8	T.	....
Indianapolis	822	154	164	29.19	30.10	.00	37.0	+ 6.3	64	13	44	16	8	31	22	33	29	75	1.01	− 2.1	12	7,861	sw.	38	sw.	11	5	4	19	7.7	0.4	....
Terre Haute	575	96	129	29.45	30.09	......	39.0	......	64	13	46	17	8	32	23	35	31	76	1.65	......	10	7,904	s.	33	s.	13	6	10	12	6.9	0.1	....
Cincinnati	628	152	160	29.43	30.13	+ .03	40.1	+ 5.7	64	14	48	20	8	33	24	36	32	76	0.94	− 2.3	9	5,291	w.	23	w.	6	7	7	14	6.7	0.3	....
Columbus	824	173	222	29.22	30.12	+ .03	36.0	+ 5.0	59	23	42	16	10	30	24	32	27	72	1.52	− 1.6	13	8,441	se.	48	e.	1	9	1	18	6.9	1.2	....
Dayton	899	181	216	29.12	30.10	......	37.0	+ 7.0	62	14	44	18	8	30	23	33	29	76	0.78	− 2.3	9	8,333	s.	40	s.	14	9	9	10	5.6	0.5	....
Pittsburgh	843	353	410	29.19	30.12	+ .03	36.8	+ 5.0	66	23	45	12	10	29	33	32	27	70	2.24	− 0.4	14	8,048	nw.	37	nw.	25	7	3	18	7.3	1.5	....
Elkins	1,940	41	50	28.02	30.15	+ .05	36.8	+ 5.3	65	21	46	5	10	27	46	32	28	80	2.62	− 0.6	14	3,098	w.	26	se.	5	7	6	15	6.9	5.5	T.
Parkersburg	638	77	84	29.46	30.14	+ .04	39.7	+ 5.8	66	23	48	15	10	32	34	35	30	74	1.80	− 1.4	11	4,099	se.	24	nw.	26	7	5	16	6.6	3.5	....
Lower Lake Region.							**29.7**	**+ 5.0**										**80**	**2.10**	**− 0.4**										**7.0**		
Buffalo	767	247	280	29.25	30.11	+ .05	29.6	+ 5.6	53	23	36	7	10	23	23	26	24	84	2.30	− 0.6	16	11,924	sw.	50	sw.	6	7	4	17	7.0	4.0	0.5
Canton	448	10	61	29.62	30.13	......	20.8	+ 2.8	49	24	29	− 9	4	12	35	....	....	....	2.43	− 0.1	14	7,334	e.	46	e.	2	8	6	14	6.2	13.1	4.4
Oswego	335	76	91	29.74	30.12	+ .06	27.4	+ 3.5	49	24	34	6	2	21	23	26	23	83	1.51	− 1.1	13	7,945	s.	33	ne.	1	5	5	18	7.4	6.9	....
Rochester	523	97	113	29.54	30.13	+ .07	29.3	+ 5.4	53	22	36	9	10	23	25	26	22	77	2.23	− 0.6	14	6,458	w.	27	ne.	1	6	3	19	7.2	9.8	1.0
Syracuse	597	97	113	29.46	30.12	+ .05	28.2	+ 4.4	55	23	35	8	10	21	23	25	22	79	2.85	+ 1.0	17	7,956	s.	40	e.	2	6	3	19	7.1	10.7	1.5
Erie	714	92	102	29.32	30.11	+ .04	31.0	+ 4.9	58	23	37	6	10	25	27	28	23	76	1.87	− 1.0	12	7,862	w.	36	s.	5	8	4	16	6.6	5.0	0.1
Cleveland	762	190	201	29.26	30.11	+ .04	32.8	+ 6.0	58	21	39	9	10	27	27	30	26	76	2.02	− 0.6	13	9,313	se.	36	nw.	25	5	5	18	7.2	4.8	....
Sandusky	629	62	103	29.40	30.11	+ .04	32.0	+ 4.9	61	13	38	11	10	26	28	29	26	80	1.89	− 0.5	12	9,015	e.	38	e.	1	5	5	18	7.2	1.5	....
Toledo	628	208	246	29.41	30.11	+ .04	32.2	+ 5.4	60	23	38	12	10	26	24	30	26	80	1.89	− 0.1	11	10,600	sw.	46	ne.	1	7	5	16	6.8	1.1	....
Fort Wayne	856	113	124	29.15	30.10	......	33.4	+ 7.6	60	13	40	15	7	26	26	30	27	81	1.90	......	14	7,818	sw.	36	sw.	14	4	5	19	7.5	2.3	....
Detroit	730	218	245	29.29	30.11	+ .05	29.9	+ 4.9	56	23	36	12	10	24	22	27	24	82	1.96	− 0.2	15	8,611	e.	42	sw.	14	6	6	16	6.9	2.2	....
Upper Lake Region.							**26.7**	**+ 7.5**										**83**	**2.09**	**+ 0.4**										**7.0**		
Alpena	609	13	92	29.43	30.12	+ .09	23.1	+ 5.3	40	14	29	2	26	17	30	22	20	86	1.96	+ 0.2	15	8,541	se.	43	ne.	1	5	9	14	6.5	7.3	0.2
Escanaba	612	54	60	29.42	30.11	+ .05	24.5	+ 9.2	40	20	30	5	2	18	23	22	20	84	2.38	+ 1.0	10	6,940	n.	36	n.	25	7	6	15	6.3	14.0	5.0
Grand Haven	632	54	92	29.37	30.08	+ .03	30.2	+ 6.0	53	21	36	9	9	24	29	27	24	81	2.81	+ 0.9	11	8,543	e.	44	sw.	15	7	3	18	7.1	5.6	....
Grand Rapids	707	70	87	29.29	30.09	+ .04	31.1	+ 5.6	56	21	37	13	10	25	25	28	24	79	2.59	+ 0.7	14	5,189	se.	27	ne.	1	5	5	18	7.4	5.1	T.
Houghton	684	62	72	29.36	30.12	+ .07	22.8	+ 6.8	43	14	29	0	28	16	32	....	....	....	1.69	0.0	13	5,428	e.	30	se.	1	7	6	15	6.9	8.7	18.0
Lansing	878	11	62	29.12	30.09	......	29.4	+ 7.8	59	23	36	9	10	22	27	26	24	85	2.10	+ 0.1	14	5,197	se.	22	sw.	15	7	3	18	7.0	3.4	T.
Ludington	637	60	66	29.36	30.07	......	28.6	......	48	21	34	10	10	23	29	27	24	84	2.54	......	13	7,572	se.	42	sw.	15	3	5	20	8.1	9.3	T.
Marquette	734	77	111	29.31	30.14	+ .09	25.4	+ 9.5	45	20	31	6	2	20	27	23	20	82	2.47	+ 0.8	14	7,249	nw.	50	sw.	10	4	4	20	8.0	21.8	16.7
Port Huron	638	70	120	29.39	30.11	+ .06	27.8	+ 5.8	53	21	34	5	10	22	29	26	23	84	1.56	− 0.6	12	8,307	nw.	34	e.	1	8	3	17	6.8	2.8	T.
Saginaw	641	48	82	29.39	30.12	......	28.2	......	55	23	35	4	26	21	31	26	24	87	2.39	+ 0.3	11	6.422	nw.	27	ne.	1	9	2	17	6.6	6.7	0.4
Sault Ste. Marie	614	11	61	29.43	30.16	+ .13	20.2	+ 6.8	38	14	28	− 5	26	12	30	18	14	80	1.16	− 0.2	7	6,510	e.	29	ne.	25	9	3	16	6.3	5.5	13.0
Chicago	823	140	310	29.16	30.08	.00	34.5	+ 9.1	59	13	40	15	7	29	24	32	28	77	1.92	− 0.2	11	8,570	se.	46	ne.	1	7	4	17	6.9	0.5	....
Green Bay	617	109	144	29.39	30.08	+ .02	27.0	+ 9.8	42	14	32	9	26	22	19	25	22	80	2.44	+ 0.8	10	8,660	ne.	51	ne.	1	7	4	17	7.3	9.2	1.5
Milwaukee	681	119	133	29.30	30.06	.00	30.4	+ 8.5	45	22	36	13	9	25	18	28	25	82	3.26	+ 1.4	11	7,800	se.	40	ne.	1	5	4	19	7.4	9.8	T.
Duluth	1,133	11	47	28.85	30.13	+ .05	20.6	+ 7.0	38	19	27	− 1	27	15	23	19	17	88	1.50	+ 0.5	7	8,644	ne.	42	w.	14	7	7	14	6.3	11.3	4.5
North Dakota.							**18.4**	**+11.4**										**86**	**0.58**	**0.0**										**6.9**		
Moorhead	940	8	57	29.08	30.14	+ .03	18.8	+11.8	38	17	26	− 5	6	12	26	18	17	91	1.88	+ 1.2	6	6,067	n.	32	nw.	14	10	6	12	5.7	16.5	8.0
Bismarck	1,674	8	57	28.28	30.14	+ .02	20.6	+12.3	37	10	28	0	8	13	34	18	15	84	0.03	− 0.5	1	5,672	nw.	38	nw.	14	8	5	15	6.7	0.4	2.5
Devils Lake	1,482	11	44	28.47	30.12	+ .01	15.4	+10.9	35	18	23	− 8	6	7	27	15	14	93	0.24	− 0.3	4	5,953	se.	35	n.	4	4	6	18	7.6	2.9	0.2
Williston	1,872	40	47	28.02	30.08	− .03	18.6	+10.7	40	17	27	− 8	7	10	37	17	13	77	0.18	− 0.3	2	3,871	se.	28	n.	14	4	5	19	7.6	1.3	0.8
Upper Mississippi Valley.							**33.2**	**+ 8.6**										**80**	**2.52**	**+ 0.8**										**6.8**		
Minneapolis	918	10	208	29.05	30.06	......	25.4	......	42	17	32	0	6	19	22	....	....	....	2.01	+ 1.3	10	8,603	se.	42	ne.	1	9	4	15	6.3	6.4	1.0
St. Paul	837	201	236	29.13	30.07	− .02	25.5	+10.5	41	19	32	2	6	19	24	....	....	....	2.21	+ 1.4	11	8,870	se.	38	se.	18	9	5	14	6.3	8.4	0.9
La Crosse	714	11	48	29.26	30.06	− .02	27.2	+ 8.8	45	17	34	− 2	9	20	30	....	....	....	3.14	+ 2.1	9	3,904	se.	21	ne.	1	8	4	16	6.6	17.6	2.0
Madison	974	70	78	28.99	30.08	− .01	27.7	+ 8.1	47	20	34	6	9	22	20	26	23	84	2.30	+ 0.8	10	7,655	se.	42	ne.	1	5	6	17	7.5	4.5	T.
Charles City	1,015	10	49	28.94	30.05	− .05	25.2	+10.1	40	13	32	− 3	9	19	31	24	22	89	4.02	+ 3.0	8	5,267	se.	28	nw.	15	8	5	15	6.4	25.0	6.0
Davenport	606	71	79	29.37	30.05	− .05	33.2	+ 9.4	54	11	39	10	8	27	21	30	28	83	2.42	+ 0.9	9	6,262	e.	29	e.	1	7	7	14	6.5	0.6	....
Des Moines	861	84	97	29.09	30.02	− .09	31.6	+ 7.5	54	11	38	8	8	25	25	29	27	84	3.20	+ 2.1	12	5,627	nw.	28	nw.	6	6	5	17	7.1	10.1	2.8
Dubuque	698	81	96	29.29	30.08	− .01	30.2	+ 8.6	49	20	36	6	9	24	22	28	24	84	2.48	+ 1.1	9	4,913	se.	26	se.	4	6	5	17	6.9	5.6	T.
Keokuk	614	64	78	29.35	30.05	− .06	36.6	+10.0	62	11	43	13	8	30	28	33	30	82	1.43	− 0.2	9	5,416	se.	27	w.	23	6	8	14	6.4	1.0	....
Cairo	356	87	93	29.70	30.10	− .02	42.7	+ 5.1	63	13	49	25	8	37	22	38	33	72	2.90	− 0.4	7	7,314	se.	36	se.	4	7	4	17	6.6	0.1	....
Peoria	609	11	45	29.38	30.07	− .03	35.4	+ 9.5	55	11	42	12	8	29	21	32	29	80	2.71	0.0	9	6,456	se.	28	nw.	14	4	5	19	7.7	0.1	....
Springfield, Ill	644	10	91	29.36	30.06	− .04	37.8	+ 8.7	66	12	44	17	8	32	20	34	30	77	2.28	− 0.5	10	6,737	se.	27	sw.	23	4	7	17	7.5	3.5	....
Hannibal	534	74	109	29.44	30.03	− .08	37.8	+ 8.7	65	12	44	16	8	31	30				1.94	+ 0.3	9	7,432	sw.	34	sw.	23	6	4	18	7.1	3.8	....
St. Louis	567	265	303	29.44	30.06	− .05	40.5	+ 7.0	69	12	47	21	8	34	26	36	32	75	2.30	− 0.4	8	10,796	s.	49	sw.	23	5	8	15	7.0	1.6	....
Missouri Valley.							**31.5**	**+ 7.1**										**85**	**2.61**	**+ 1.6**										**6.7**		
Columbia, Mo	781	11	84	29.17	30.02	− .09	39.4	+ 9.3	69	12	46	19	8	32	30				2.14	0.0	10	7,142	se.	34	sw.	14	4	7	17	7.5	2.4	....
Kansas City	963	161	181	28.96	30.02	− .09	38.2	+ 8.3	63	11	45	16	6	32	25	35	31	79	2.87	+ 1.3	12	9,781	nw.	39	se.	4	6	6	16	6.8	6.5	T.
St. Joseph	967	11	49	28.96	30.03		35.7		62	11	42	13	6	29	28	33	29	79	2.63		13	7,599	nw.	40	w.	6	6	6	16	7.1	7.7	0.5
Springfield, Mo	1,324	98	104	28.61	30.05	− .06	39.8	+ 6.2	65	12	47	22	8	32	28	35	31	75	2.66	+ 0.4	9	9,780	se.	38	sw.	22	11	6	11	5.4	6.0	1.5
Iola	984	11	50	28.95	30.02	− .08	39.6	+ 7.6	66	10	47	20	8	32	30				4.26	+ 3.2	11	6,493	nw.	30	s.	4	10	4	14	5.8	10.1	T.
Topeka	983	85	101				37.0	+ 7.0	66	10	44	18	6	30	32				2.48	+ 1.1	11	7,983	nw.	38	s.	4	8	4	16	6.7	8.9	T.
Lincoln	1,189	11	84	28.73	30.04	− .06	31.0	+ 6.2	50	17	37	8	8	25	24	29	27	88	2.53	+ 1.8	14	8,086	se.	52	nw.	5	7	5	16	7.1	13.5	5.8
Omaha	1,105	115	121	28.82	30.04	− .07	31.0	+ 7.3	51	17	37	8	8	25	23	29	26	85	2.62	+ 1.9	14	6,531	nw.	37	nw.	5	5	7	16	7.3	11.5	3.5
Valentine	2,598	47	54	27.26	30.08	− .01	24.6	+ 3.4	50	10	33	− 3	2	16	36	23	22	91	1.35	+ 0.8	14	6,605	nw.	42	nw.	14	8	5	15	6.6	9.9	3.6
Sioux City	1,135	94	164	28.79	30.06	− .06	26.8	+ 7.0	43	17	32	2	8	22	23	26	24	89	3.12	+ 2.6	12	9,663	nw.	55	nw.	5	8	5	15	6.7	12.1	T.
Huron	1,306	59	74	28.66	30.12		22.0	+ 9.1	39	18	28	− 4	2	16	28	21	19	89	1.43	+ 1.0	9	8,096	nw.	43	nw.	4	3	10	15	6.8	8.0	0.9
Pierre	1,572	70	75	28.39	30.13	+ .02	23.4	+ 6.5	43	17	30	0	16	17	29	22	20	89	1.81	+ 1.4	7	6,407	nw.	40	nw.	5	11	3	14	6.2	19.1	5.0
Yankton	1,233	49	57	28.69	30.06	− .06	25.0	+ 6.8	44	10	31	0	8	19	29				4.00	+ 3.4	10	6,080	nw.	38	nw.	5	3	7	18	7.7	30.1	4.8

TABLE I.—*Climatological data for United States Weather Bureau stations, February, 1915*—Continued.

Districts and stations.	Elevation of instruments. Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Pressure in inches. Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air, in degrees Fahrenheit. Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Precipitation, inches. Total.	Departure from normal.	Days with 0.01 or more.	Wind. Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
Northern Slope.							**27.2**	**+ 5.7**										**75**	**0.77**	**0.0**										**5.6**		
Havre	2,505	11	44	27.32	30.08	+0.01	16.6	+ 1.6	43	17	25	− 7	1	8	39	16	15	91	0.44	0.0	3	3,789	nw.	30	sw.	5	9	9	10	6.1	4.4	3.0
Helena	4,110	87	114	25.72	30.01	− .10	31.4	+ 9.2	51	17	40	13	14	23	25	27	22	71	0.36	− 0.4	3	4,378	sw.	31	sw.	4	9	12	7	5.5	4.6	....
Kalispell	2,962	11	34	26.86	29.99	− .09	28.4	+ 4.6	45	19	37	4	15	20	30	26	23	80	1.01	− 0.4	9	1,989	w.	17	w.	13	6	9	13	6.4	10.1	3.9
Miles City	2,371	26	48	27.48	30.14	− .05	21.6	+ 4.8	45	17	32	− 9	1	11	40	19	15	78	1.30	+ 0.7	2	2,500	sw.	24	nw.	13	10	14	4	4.7	10.9	1.0
Rapid City	3,259	50	58	26.56	30.10	+ .02	28.6	+ 5.1	60	10	37	9	15	20	37	25	20	70	0.95	+ 0.5	5	5,441	n.	37	nw.	5	9	6	13	5.9	9.2	T.
Cheyenne	6,088	84	101	23.91	30.02	− .01	31.2	+ 4.9	60	10	41	13	12	21	34	25	18	63	0.97	+ 0.4	7	9,363	nw.	52	w.	3	13	9	6	4.8	9.8	T.
Lander	5,372	60	68	24.56	30.02	− .06	30.8	+ 9.0	54	17	43	2	5	18	37	25	17	61	0.44	− 0.2	4	2,913	sw.	26	nw.	4	12	9	7	5.2	3.8	....
Sheridan	3,790	10	47	26.06	30.11	......	22.5	......	47	17	35	− 5	15	10	43	20	16	81	0.17	......	6	2,638	se.	36	nw.	4	9	9	10	5.3	2.3	3.0
Yellowstone Park	6,200	11	48	23.78	30.05	− .05	26.4	+ 6.8	46	9	36	2	5	17	28	23	18	73	0.39	− 1.4	6	4,484	s.	24	s.	1	8	14	6	5.4	3.3	0.5
North Platte	2,821	11	51	27.06	30.09	+ .02	29.7	+ 5.1	60	10	38	− 1	2	21	37	26	24	84	1.11	+ 0.7	8	5,559	nw.	37	nw.	5	8	5	15	6.4	5.8	0.6
Middle Slope.							**38.3**	**+ 6.0**										**69**	**2.20**	**+ 1.4**										**5.4**		
Denver	5,291	129	172	24.64	30.00	− .01	36.1	+ 5.0	69	10	47	10	15	25	39	29	21	59	1.19	+ 0.7	7	5,210	sw.	44	nw.	4	12	8	8	4.5	14.0	1.0
Pueblo	4,685	80	86	25.21	29.98	− .02	36.5	+ 4.7	73	9	51	9	15	22	60	28	17	52	0.57	+ 0.1	6	4,105	nw.	39	nw.	4	13	10	5	4.0	4.6	T.
Concordia	1,398	42	50	28.52	30.03	− .06	35.1	+ 6.3	56	16	42	17	2	29	25	32	30	84	2.34	+ 1.6	9	5,807	nw.	31	s.	17	5	4	19	7.4	8.6	3.2
Dodge	2,509	11	51	27.37	30.03	− .03	39.0	+ 7.9	75	10	49	18	2	29	45	33	28	72	1.37	+ 0.7	8	8,182	n.	40	s.	12	10	8	10	5.5	3.3	0.3
Wichita	1,358	139	158	28.54	30.00	− .08	39.6	+ 6.6	71	10	47	19	2	32	29	35	31	77	4.61	+ 3.5	10	10,822	s.	50	sw.	4	9	6	13	5.9	4.6	0.3
Oklahoma	1,214	10	47	28.73	30.01	− .03	43.8	+ 5.3	70	10	52	24	1	35	37	38	33	72	3.10	+ 2.1	9	11,659	s.	48	s.	12	13	4	11	4.9	0.3	....
Southern Slope.							**48.4**	**+ 3.8**										**56**	**0.96**	**+ 0.1**										**3.9**		
Abilene	1,738	10	52	28.20	30.03	− .02	51.6	+ 6.8	79	3	63	28	6	40	38	42	32	56	0.96	− 0.1	4	7,809	s.	37	s.	11	10	8	10	4.9	....	....
Amarillo	3,676	10	49	26.22	30.01	− .01	41.4	+ 4.2	76	10	54	20	28	29	45	34	26	65	1.60	+ 0.7	3	8,179	nw.	44	nw.	1	20	6	2	3.4	9.9	....
Del Rio	944	64	71	29.03	30.03	+ .03	56.7	+ 3.1	77	3	68	32	7	46	37	....	....	....	0.31	− 0.6	3	6,764	se.	38	w.	4	17	6	5	3.4	....	....
Roswell	3,566	75	85	26.34	29.99	+ .01	43.8	+ 1.3	73	17	58	16	6	30	51	35	20	46	0.95	+ 0.4	4	5,868	nw.	48	w.	3	15	7	6	3.9	T.	....
Southern Plateau.							**42.8**	**− 2.0**										**60**	**0.78**	**+ 0.1**										**3.7**		
El Paso	3,762	110	133	26.18	29.98	+ .03	47.8	− 1.1	71	10	59	26	6	36	34	38	25	46	0.59	+ 0.1	6	7,478	w.	52	sw.	21	14	10	4	3.8	....	....
Santa Fe	7,013	57	62	23.17	30.02	+ .04	32.4	+ 0.4	56	10	42	9	6	23	37	27	21	66	0.77	− 0.1	9	5,674	n.	34	s.	11	10	11	7	4.8	6.4	T.
Flagstaff	6,908	8	57	......	......	......	25.7	− 5.1	49	8	38	− 4	22	13	45	....	....	....	2.38	......	11	......	sw.	44	w.	3	13	9	6	....	23.9	12.0
Phoenix	1,108	76	81	28.82	29.99	.00	53.8	− 0.6	75	9	64	34	4	43	29	46	38	60	1.21	+ 0.5	4	3,406	e.	18	w.	3	14	6	8	3.9	....	....
Yuma	141	9	58	29.85	30.00	.00	56.8	− 2.4	73	9	69	37	4	45	30	48	38	57	0.72	+ 0.1	3	3,759	w.	28	se.	2	23	4	1	1.8	....	....
Independence	3,910	11	42	25.90	29.92	− .14	40.2	− 3.5	60	26	52	22	4	29	33	36	31	73	0.59	− 0.2	5	5,247	se.	42	se.	2	10	13	5	4.4	....	....
Middle Plateau.							**35.9**	**+ 2.9**										**72**	**1.55**	**+ 0.4**										**6.4**		
Reno	4,532	74	81	25.35	29.95	− .13	37.2	+ 1.6	56	7	46	11	13	28	30	32	28	74	2.59	+ 0.8	13	4,394	w.	50	s.	7	5	8	15	7.1	9.5	....
Tonopah	6,090	12	20	23.96	29.97	......	34.1	......	49	14	40	16	21	28	19	31	27	75	0.50	− 0.3	4	9,229	se.	48	se.	9	7	12	9	5.7	5.0	....
Winnemucca	4,344	18	56	25.51	29.94	− .15	37.6	+ 4.3	59	7	47	15	14	28	34	32	27	72	1.13	+ 0.2	13	4,524	sw.	40	sw.	2	4	5	19	7.5	4.0	....
Modena	5,479	10	43	24.55	29.98	− .06	31.8	+ 0.2	48	23	42	2	14	22	36	28	23	73	2.56	+ 1.4	11	5,851	w.	72	sw.	2	9	7	12	5.9	11.6	....
Salt Lake City	4,360	147	189	25.57	29.99	− .09	38.2	+ 5.3	56	9	45	17	5	31	24	33	27	65	2.00	+ 0.6	11	4,155	se.	36	se.	2	5	9	14	6.5	7.5	T.
Durango	6,546	10	....	......	......	......	......	......	....	....	....	....	....	....	....	....	....	....	......	......	....	......	....	....	....	....	....	....	....	....	......	....
Grand Junction	4,602	82	96	25.37	30.01	− .03	34.8	+ 3.3	58	11	43	15	8	26	31	30	25	73	0.53	− 0.1	8	3,917	w.	39	w.	3	10	7	11	5.5	1.1	....
Northern Plateau.							**39.0**	**+ 6.9**										**72**	**1.36**	**− 0.1**										**7.4**		
Baker	3,471	48	53	26.36	29.99	− .13	36.2	+ 8.3	53	17	43	18	14	29	24	32	26	68	1.17	− 0.2	13	4,010	se.	30	se.	8	4	9	15	7.0	2.0	T.
Boise	2,739	78	86	27.10	29.99	− .13	40.8	+ 7.0	57	8	48	25	15	34	25	36	28	62	1.95	+ 0.5	12	4,670	se.	32	e.	2	2	6	20	8.4	0.8	....
Lewiston	757	40	48	29.13	29.95	− .16	42.1	+ 5.9	59	8	51	25	14	34	28	....	....	....	1.15	− 0.2	7	2,108	e.	18	w.	3	5	10	13	6.6	......	....
Pocatello	4,477	46	54	25.41	30.00	− .10	35.8	+ 7.7	51	8	43	16	5	28	27	31	25	68	0.72	− 0.1	7	6,024	se.	38	sw.	3	5	9	14	6.9	1.6	....
Spokane	1,929	101	110	27.88	29.96	− .13	37.2	+ 7.1	51	20	43	16	14	31	21	34	30	76	1.37	− 0.6	14	3,428	e.	23	sw.	3	0	8	20	8.1	2.5	....
Walla Walla	1,000	57	65	28.84	29.92	− .19	42.0	+ 5.6	64	8	49	27	14	35	29	40	37	86	1.79	+ 0.2	10	2,885	s.	26	se.	8	3	7	18	7.7	......	....
North Pacific Coast Region.							**44.1**	**+ 3.4**										**82**	**3.84**	**− 1.7**										**7.8**		
North Head	211	11	56	29.66	29.89	− .17	45.2	+ 3.1	56	15	48	35	14	42	17	44	42	89	5.82	0.0	20	10,240	e.	75	se.	8	4	4	20	7.6	......	....
Port Crescent	259	8	53	29.59	29.87	− .16	40.1	+ 2.9	52	24	47	28	14	34	18	....	....	....	2.58	− 2.1	20	3,615	s.	17	se.	2	0	11	17	8.1	......	....
Seattle	125	215	250	29.77	29.90	− .16	44.5	+ 4.0	61	8	50	29	14	39	19	42	39	82	2.76	− 1.1	17	5,312	se.	42	sw.	22	0	8	20	8.3	......	....
Tacoma	213	113	120	29.67	29.90	− .16	43.4	+ 3.0	58	8	50	27	14	37	24	42	39	84	3.24	− 1.9	18	3,513	sw.	31	sw.	3	0	12	16	7.8	......	....
Tatoosh Island	109	7	57	29.73	29.83	− .17	45.0	+ 4.0	55	7	48	38	4	42	9	42	40	83	6.11	− 2.6	21	11,792	e.	58	s.	5	3	7	18	7.8	......	....
Portland, Oreg.	153	68	106	29.73	29.89	− .19	45.4	+ 4.1	60	8	51	30	15	40	22	42	38	76	3.07	− 2.7	18	3,507	se.	30	sw.	8	3	10	15	7.5	......	....
Roseburg	510	9	57	29.34	29.90	− .20	45.0	+ 2.4	65	6	52	29	21	38	30	42	38	77	3.33	− 1.2	17	2,225	s.	26	se.	8	0	18	10	7.2	......	....
Middle Pacific Coast Region.							**49.3**	**+ 0.3**										**85**	**8.14**	**+ 3.8**										**7.2**		
Eureka	62	73	89	29.87	29.94	− .17	48.4	+ 1.6	62	15	54	36	11	43	20	46	43	83	12.39	+ 5.4	19	5,650	se.	39	nw.	2	4	3	21	8.0	......	....
Mt. Tamalpais	2,375	11	18	27.46	29.96	− .14	42.6	− 3.0	51	13	46	32	20	39	12	41	40	94	6.96	+ 1.2	20	12,192	se.	68	sw.	2	1	6	21	8.6	T.	....
Point Reyes Light	490	7	18	29.41	29.92	......	49.8	+ 0.6	58	14	54	40	10	46	12	....	....	....	5.31	......	18	18,259	s.	95	sw.	2	4	10	14	6.5	......	....
Red Bluff	332	50	56	29.59	29.96	− .15	48.4	− 0.9	64	26	54	32	21	42	26	46	45	88	10.87	+ 7.2	18	4,488	se.	32	se.	2	5	7	16	6.9	......	....
Sacramento	69	106	117	29.91	29.98	− .11	51.0	+ 0.8	62	26	57	35	21	45	18	48	44	81	4.26	+ 1.1	20	6,001	se.	57	se.	8	6	9	13	6.4	......	....
San Francisco	155	209	213	29.81	29.98	− .12	52.8	+ 1.5	62	6	58	44	21	48	16	49	46	79	7.36	+ 3.7	19	5,971	se.	51	sw.	2	7	5	16	6.7	......	....
San Jose	141	12	110	29.86	30.01	......	52.0	+ 1.4	65	17	59	35	21	45	25	....	....	....	7.02	+ 4.5	19	5,305	se.	48	se.	8	4	7	17	7.2	......	....
South Pacific Coast Region.							**53.7**	**+ 1.1**										**77**	**5.42**	**+ 3.0**										**6.1**		
Fresno	327	89	98	29.66	30.02	− .06	52.2	+ 3.0	74	7	60	36	21	44	27	47	42	72	3.47	+ 2.1	13	4,157	e.	36	w.	20	3	11	14	6.6	......	....
Los Angeles	338	159	191	29.66	30.02	− .04	54.7	+ 0.6	72	6	62	41	21	48	26	50	46	76	5.09	+ 2.2	8	4,711	ne.	28	se.	2	6	10	12	6.1	......	....
San Diego	87	62	70	29.94	30.03	− .03	55.4	+ 0.8	75	6	62	42	4	49	25	51	47	78	3.62	+ 1.7	13	4,890	nw.	38	s.	2	14	4	10	5.0	......	....
San Luis Obispo	201	32	40	29.82	30.04	− .07	52.4	− 0.1	70	14	60	35	21	44	30	49	46	81	9.51	+ 5.9	16	3,190	se.	25	s.	7	6	7	15	6.8	......	....
West Indies.																																
San Juan	82	8	54	29.89	29.98	− .17	74.6	......	87	3	80	64	25	70	17	....	....	....	6.01	+ 3.5	15	7,553	ne.	33	ne.	15	10	12	6	4.9	......	....
Panama.																																
Balboa Heights	118	7	97	29.72	29.84	......	81.3	......	92	5	89	70	1	74	20	74	73	86	2.96	+ 3.2	11	5,921	n.	31	n.	26	1	20	7	6.1	......	....
Colon	25	5	71	29.82	29.85	......	81.4	......	87	17	85	72	10	77	14	77	75	85	12.37	+10.1	15	10,278	n.	39	n.	9	11	14	3	4.6	......	....

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during February, 1915, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex.	12	6:30 p. m.	7:05 p. m.	0.40	6:44 p. m.	6:54 p. m.	0.02	0.15	0.37												
Albany, N. Y.	24-25			0.84														0.17			
Alpena, Mich.	5-8			0.76														(*)			
Amarillo, Tex.	20			0.83														(*)			
Anniston, Ala.	31[1]-1	4:45 p. m.	6:15 a. m.	2.15	12:12 a. m.	12:56 a. m.	.23	.07	.10	0.28	0.56	0.64	0.67	0.72	0.77	0.84					
Asheville, N. C.	31[1]-1			1.36														.26			
Atlanta, Ga.	22-24	9:15 p. m.	D. N. a. m.	1.76	[2]9:44 p. m.	[2]10:18 p. m.	.78	.23	.25	.31	.36	.39	.51	.75							
Atlantic City, N. J.	1-2			1.82														.36			
Augusta, Ga.	1-2			1.64														.55			
Baker, Oreg.	1-2			0.42														(*)			
Baltimore, Md.	1-2			2.33														.44			
Bentonville, Ark.	22			1.13														.46			
Binghamton, N. Y.	31[1]-2			1.11														(*)			
Birmingham, Ala.	4-5			0.81														.28			
Bismarck, N. Dak.	4			0.03														(*)			
Block Island, R. I.	31[1]-2			2.29														.32			
Boise, Idaho	18			0.58														.24			
Boston, Mass.	31[1]-3			2.02														(*)			
Buffalo, N. Y.	31[1]-3			1.32														(*)			
Burlington, Vt.	23-26			2.10														(*)			
Cairo, Ill.	22-23			1.48														(*)			
Canton, N. Y.	31[1]-1			0.58														(*)			
Charles City, Iowa	31[1]-1			1.39														(*)			
Charleston, S. C.	1-2	10:50 p. m.	D. N. a. m.	0.71	11:22 p. m.	11:53 p. m.	.01	.09	.11	.16	.20	.38	.64	.68							
Charlotte, N. C.	1-2			1.37														.30			
Chattanooga, Tenn.	31[1]-1			2.10														.54			
Cheyenne, Wyo.	12-13			0.60														(*)			
Chicago, Ill.	22-23			1.31														(*)			
Cincinnati, Ohio	5			0.52														.08			
Cleveland, Ohio	31[1]-2			1.56														.15			
Columbia, Mo.	22			0.66														(*)			
Columbia, S. C.	1			1.08														.30			
Columbus, Ohio	30[1]-2			1.03														(*)			
Concord, N. H.	24-25			1.47														(*)			
Concordia, Kans.	27			0.51														(*)			
Corpus Christi, Tex.	27			0.12														.09			
Davenport, Iowa	[1]30-2			2.47														(*)			
Dayton, Ohio	5			0.15														(*)			
Del Rio, Tex.	19-20			0.15														0.08			
Denver, Colo.	12-13			0.50														(*)			
Des Moines, Iowa	22-23			1.23														(*)			
Detroit, Mich.	5-8			0.79														(*)			
Devils Lake, N. Dak.	3-5			0.21														(*)			
Dodge City, Kans.	26-28			0.71														(*)			
Dubuque, Iowa	[1]30-1			1.66														(*)			
Duluth, Minn.	13-14			0.70														(*)			
Durango, Colo.																					
Eastport, Me.	6			0.40														.17			
Elkins, W. Va.	1-3			1.17														(*)			
El Paso, Tex.	26			0.21														.12			
Erie, Pa.	[1]31-1			1.33														(*)			
Escanaba, Mich.	14-15			0.78														(*)			
Eureka, Cal.	[1]31-2	10:05 a. m.	8:55 a. m.	6.23	8:48 a. m.[3]	9:31 a. m.[3]	2.47	.06	.19	.31	.43	.52	.63	.69	.75	.79					
Evansville, Ind.	1	3:10 p. m.	3:45 p. m.	0.36	3:31 p. m.	3:38 p. m.	.01	.29	.35												
Flagstaff, Ariz.	11-12			0.79														(*)			
Fort Smith, Ark.	13			0.49														.34			
Fort Wayne, Ind.	[1]30-2			1.77														(*)			
Fort Worth, Tex.	26-27			0.80														(*)			
Fresno, Cal.	8-9			1.99														.26			
Galveston, Tex.	26-27	3:55 p. m.	7:55 a. m.	1.38	4:16 a. m.	4:27 a. m.	.29	.46	.77	.82											
Grand Haven, Mich.	1			0.77														(*)			
Grand Junction, Colo.	12			0.26														.09			
Grand Rapids, Mich.	22-23			0.77														.20			
Green Bay, Wis.	23			0.61														(*)			
Hannibal, Mo.	20-21			0.51														.13			
Harrisburg, Pa.	1-3			2.53														(*)			
Hartford, Conn.	[1]31-2			1.85														(*)			
Hatteras, N. C.	24			0.68														.36			
Havre, Mont.	3-4			0.42														(*)			
Helena, Mont.	3			0.35														(*)			
Houghton, Mich.	13-14			0.46														(*)			
Houston, Tex.	22	8:55 a. m.	2:50 p. m.	1.15	12:52 p. m.	1:31 p. m.	.17	.20	.49	.60	.61	.61	.65	.79	.86						
	26-27	12:20 p. m.	5:55 a. m.	1.52	2:58 a. m.	3:20 a. m.	.43	.09	.33	.52	.62	.65									
Huron, S. Dak.	12-14			0.85														(*)			
Independence, Cal.	28			0.42														0.22			
Indianapolis, Ind.	4-6			0.52														(*)			
Iola, Kans.	22			1.79														(*)			
Jacksonville, Fla.	16			0.75														(*)			
Kalispell, Mont.	2-3			0.48														(*)			
Kansas City, Mo.	22-23			1.15														(*)			
Keokuk, Iowa	20-21			0.61														(*)			
Key West, Fla.	16	D. N. a. m.	9:55 a. m.	0.75	5:55 a. m.	6:11 a. m.	.11	.13	.26	.39	.44										
	23	4.10 p. m.	8:35 p. m.	1.06	4:48 p. m.	5:14 p. m.	.11	.08	.12	.15	.38	.52	.55								
Knoxville, Tenn.	1			1.35														.41			
La Crosse, Wis.	21-23			1.69														(*)			
Lander, Wyo.	20-21			0.20														(*)			
Lansing, Mich.	[1]30-2			1.13														(*)			
Lewiston, Idaho	1			0.41														.08			
Lexington, Ky.	4-5			0.65														.11			
Lincoln, Nebr.	26-28			1.14														(*)			
Little Rock, Ark.	13			0.57														(*)			
Los Angeles, Cal.	9-10			2.29														.49			
Louisville, Ky.	4-5			0.55														.12			
Ludington, Mich.	[1]31-1			1.26														(*)			
Lynchburg, Va.	23-24			1.14														(*)			
Macon, Ga.	1			1.57														.71			
Madison, Wis.	22-23			0.59														.15			

[1] January. [2] Jan. 23. [3] Feb. 1. * Self-register not working.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during February, 1915, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Marquette, Mich.	23-24			1.34														(*)			
Memphis, Tenn.	13	1:45 p. m.	6:35 p. m.	1.18	2:15 p. m.	2:30 p. m.	0.03	0.12	0.26	0.35											
Meridian, Miss.	4-5			1.23														0.33			
Miami, Fla.	16	6:05 a. m.	12:20 p. m.	1.94	9:22 a. m.	10:14 a. m.	.67	.11	.16	.23	0.37	0.46	0.53	0.69	0.73	0.84	0.92	.98			
Milwaukee, Wis.	[1] 30-2			2.53														(*)			
Minneapolis, Minn.	13			0.60														(*)			
Mobile, Ala.	4-5			1.28														(*)			
Modena, Utah	9-11			1.84														(*)			
Montgomery, Ala.	[1] 31-1	10:30 p. m.	5:40 a. m.	1.60	1:34 a. m.	1:02 a. m.	.17	.09	.24	.48	.56	.63	.68								
	23	9:20 a. m.	8:40 p. m.	1.13	6:59 p. m.	7:13 p. m.	.33	.28	.57	.66											
Moorhead, Minn.	13-14			1.46														(*)			
Mount Tamalpais, Cal.	[1] 31-1			1.19																	
Nantucket, Mass.	[1] 31-4			2.59														.31			
Nashville, Tenn.	[1] 31-1			1.50														(*)			
New Haven, Conn.	[1] 31-2			3.85														.45			
New Orleans, La.	4	7:55 p. m.	D. N. p. m.	1.25	9:52 p. m.	10:12 p. m.	.29	.13	.25	.42	.49										
	21	3:35 p. m.	7:25 p. m.	0.90	3:38 p. m.	4:03 p. m.	.01	.26	.46	.49	.61	.68									
New York, N. Y.	[1] 31-2			3.72														0.47			
Norfolk, Va.	16			0.94														(*)			
Northfield, Vt.	24-25			1.88														(*)			
North Head, Wash.	2-5			2.64														(*)			
North Platte, Nebr.	4			0.50														(*)			
Oklahoma, Okla.	26-28			0.93														(*)			
Omaha, Nebr.	26-27			0.90														(*)			
Oswego, N. Y.	23-24			0.47														(*)			
Palestine, Tex.	13	2:10 a. m.	10:20 a. m.	1.64	5:27 a. m.	5:57 a. m.	.23	.19	.25	.32	.39	.47	.55								
Parkersburg, W. Va.	[1] 30-3			1.54														(*)			
Pensacola, Fla.	[1] 31-1			1.52														.32			
Peoria, Ill.	[1] 30-2			1.53														(*)			
Philadelphia, Pa.	1-2			3.81														.39			
Phoenix, Ariz.	19			0.64														.35			
Pierre, S. Dak.	12-13			1.10														(*)			
Pittsburgh, Pa.	1			1.07														.29			
Pocatello, Idaho	25			0.24														.14			
Point Reyes Light, Cal.	7			0.65														.32			
Port Huron, Mich.	23			0.67														(*)			
Portland, Me.	6			0.56														.25			
Portland, Oreg.	[1] 31-1			1.10														(*)			
Providence, R. I.	24-25			1.36														(*)			
Pueblo, Colo.	21-22			0.31														(*)			
Raleigh, N. C.	1	12:14 p. m.	10 p. m.	1.07	5:36 p. m.	6:09 p. m.	.17	.05	.11	.21	.32	.40	.56	.61							
Rapid City, S. Dak.	12			0.85														(*)			
Reading, Pa.	1-2			3.40														.35			
Red Bluff, Cal.	1-2			2.49														(*)			
Reno, Nev.	7-9			1.09														(*)			
Richmond, Va.	1-3			1.60														.29			
Rochester, N. Y.	[1] 31-2			1.21														(*)			
Roseburg, Oreg.	[1] 31-1			1.48														.23			
Roswell, N. Mex.	19-20			0.56														.18			
Sacramento, Cal.	7-10			1.54														.24			
Saginaw, Mich.	23			0.72														(*)			
St. Joseph, Mo.	26			0.54														(*)			
St. Louis, Mo.	22-23			1.43														.30			
St. Paul, Minn.	13-15			1.13														(*)			
Salt Lake City, Utah	10-12			0.76														(*)			
San Antonio, Tex.	26			1.35														.22			
San Diego, Cal.	2	5:30 a. m.	10:45 a. m.	0.91	8:35 a. m.	9:03 a. m.	.33	.20	.33	.36	.39	.45	.49								
Sand Key, Fla.	6			0.51														.45			
Sandusky, Ohio	[1] 30-2			1.82														(*)			
San Francisco, Cal.	16	10:46 a. m.	12:35 p. m.	0.55	12:13 p. m.	12:30 p. m.	.02	.09	.23	.38	.53										
San Jose, Cal.	8-9			1.93														.34			
San Luis Obispo, Cal.	8-9			4.02														.43			
Santa Fe, N. Mex.	19-20			0.19														(*)			
Sault Ste. Marie, Mich.	13-14			0.59														(*)			
Savannah, Ga.	16			0.51														(*)			
Scranton, Pa.	1			1.02														(*)			
Seattle, Wash.	4-6			1.08														(*)			
Sheridan, Wyo.	20-21			0.06														(*)			
Shreveport, La.	13			1.45														.38			
Sioux City, Iowa	12-13			1.16														(*)			
Spokane, Wash.	18-19			0.28														(*)			
Springfield, Ill.	22-23			1.16														(*)			
Springfield, Mo.	22			0.96														.42			
Syracuse, N. Y.	[1] 31-3			2.10														(*)			
Tacoma, Wash.	4-5			1.06														(*)			
Tampa, Fla.	5	3:10 p. m.	8:10 p. m.	0.97	3:37 p. m.	4:03 p. m.	.07	.14	.18	.29	.44	.56	.60								
Tatoosh Island, Wash.	22-24			1.58														(*)			
Taylor, Tex.	26-27			0.87														(*)			
Terre Haute, Ind.	22-23			0.88														.22			
Thomasville, Ga.	5	8:28 a. m.	10:50 a. m.	0.50	8:37 a. m.	8:47 a. m.	.01	.24	.30												
Toledo, Ohio	[1] 31-1			1.55														.13			
Tonopah, Nev.	20			0.24														(*)			
Topeka, Kans.	22			0.61														(*)			
Valentine, Nebr.	12-13			0.78														(*)			
Vicksburg, Miss.	22			0.59														.50			
Walla Walla, Wash.	1-2			0.78														(*)			
Washington, D. C.	1-2			1.47														.30			
Wichita, Kans.	18			1.46														(*)			
Williston, N. Dak.	4			0.10														(*)			
Wilmington, N. C.	2	D.N. a. m.	6:55 a. m.	0.57	2:28 a. m.	2:49 a. m.	.01	.13	.19	.23	.44	.47									
Winnemucca, Nev.	20			0.28														(*)			
Wytheville, Va.	24-25			0.74														.13			
Yankton, S. Dak.	12-14			1.78														(*)			
Yellowstone Park, Wyo.	2			.18														(*)			

[1] January.

* Self-register not working.

TABLE III.—*Data furnished by the Canadian Meteorological Service, February, 1915.*

Stations.	Pressure.			Temperature.						Precipitation.		
	Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Inches.	*Inches.*	*Inches.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*Inches.*	*Inches.*	*Inches.*
St. Johns, N. F.	29.82	29.97	+0.14	24.6	+ 2.6	30.7	18.4	48	−10	4.92	+0.01	10.0
Sydney, C. B. I.	30.03	30.07	+ .15	25.8	+ 6.5	32.9	18.6	49	− 9	2.72	−1.37	7.0
Halifax, N. S.	29.98	30.09	+ .14	27.8	+ 5.4	36.1	19.5	47	−11	3.88	−1.28	11.0
Yarmouth, N. S.	30.01	30.08	+ .09	29.4	+ 3.6	35.6	23.1	49	2	2.88	−1.86	7.2
Charlottetown, P. E. I.	30.04	30.08	+ .13	22.8	+ 5.2	28.6	17.0	46	−12	2.51	−0.55	11.3
Chatham, N. B.	30.10	30.13	+ .17	20.2	+ 7.7	29.6	10.8	44	−24	2.56	−0.60	11.7
Father Point, Que.	29.99	30.02	+ .04	16.6	+ 5.1	24.1	9.0	37	−18	1.72	−0.49	16.4
Quebec, Que.	29.77	30.11	+ .12	18.6	+ 6.8	25.4	11.8	35	−12	3.00	−0.27	14.5
Montreal, Que.	29.90	30.12	+ .10	21.3	+ 6.8	27.5	15.1	42	−10	4.32	+1.25	17.7
Stonecliffe, Ont.	29.53	30.16	+ .15	16.7	+ 6.8	27.0	6.4	42	−20	1.70	−0.30	16.0
Ottawa, Ont.	29.88	30.23	+ .21	19.8	+ 8.1	27.2	12.3	41	−12	2.92	+0.23	15.9
Kingston, Ont.	29.82	30.16	+ .12	24.0	+ 6.2	31.4	16.7	45	− 5	1.64	−0.90	6.4
Toronto, Ont.	29.70	30.10	+ .06	26.0	+ 4.5	31.8	20.3	42	3	2.65	+0.04	8.6
White River, Ont.	28.75	30.13	+ .11	10.4	+10.2	25.0	− 4.2	42	−33	0.70	−0.82	6.0
Port Stanley, Ont.	29.44	30.10	+ .04	26.8	+ 4.0	33.3	20.4	45	− 1	4.16	+0.95	15.4
Southampton, Ont.	29.38	....	....	19.7	− 0.2	32.4	7.0	47	− 2	3.00	+0.10	15.3
Parry Sound, Ont.	29.40	30.14	+ .13	21.0	+ 6.7	30.0	12.0	45	−11	2.34	−0.58	15.0
Port Arthur, Ont.	29.42	30.16	+ .11	20.0	+13.6	29.0	11.0	38	−16	0.79	−0.11	5.0
Winnipeg, Man.	29.28	30.16	+ .06	14.6	+16.2	22.6	6.7	38	−13	1.06	+0.08	10.6
Minnedosa, Man.	28.23	30.14	+ .05	13.1	+15.8	22.0	4.2	34	−19	0.20	−0.41	2.0
Qu'Appelle, Sask.	27.71	30.04	− .04	18.3	+18.9	25.8	10.8	39	− 5	0.44	−0.29	4.4
Medicine Hat, Alberta.	27.64	29.99	− .06	22.6	+11.4	36.4	8.7	43	− 9	1.15	+0.48	11.5
Swift Current, Sask.	27.34	30.02	− .05	18.8	+10.8	27.0	10.7	40	3	0.16	−0.58	1.6
Calgary, Alberta.	26.30	29.96	− .03	24.4	+10.9	34.8	14.0	46	0	0.23	−0.49	2.3
Banff, Alberta.	25.25	29.98	.00	23.4	+ 4.2	35.0	11.9	43	− 8	0.75	−0.17	7.5
Edmonton, Alberta.	27.60	29.99	− .03	15.2	+ 6.9	27.6	2.9	41	−13	0.02	−0.65	0.2
Prince Albert, Sask.	28.41	30.04	− .05	12.1	+15.1	19.6	4.6	33	−12	0.25	−0.44	2.5
Battleford, Sask.	28.25	30.07	− .02	13.8	+13.7	24.4	3.2	35	−15	0.12	−0.25	1.2
Kamloops, B. C.	28.67	29.99	+ .03	36.8	+ 8.5	42.0	31.7	51	24	T.	−0.79	T.
Victoria, B. C.	29.61	29.87	− .13	43.3	+ 3.8	47.7	39.0	52	34	0.98	−3.12	....
Barkerville, B. C.	25.40	29.76	− .15	25.0	+ 6.1	32.6	17.5	42	1	1.74	−1.32	17.4
Hamilton, Bermuda.	29.91	30.08	− .03	61.8	+ 0.3	67.2	56.4	72	50	3.52	−0.92	....

Chart I. Hydrographs of Several Principal Rivers, February, 1915.

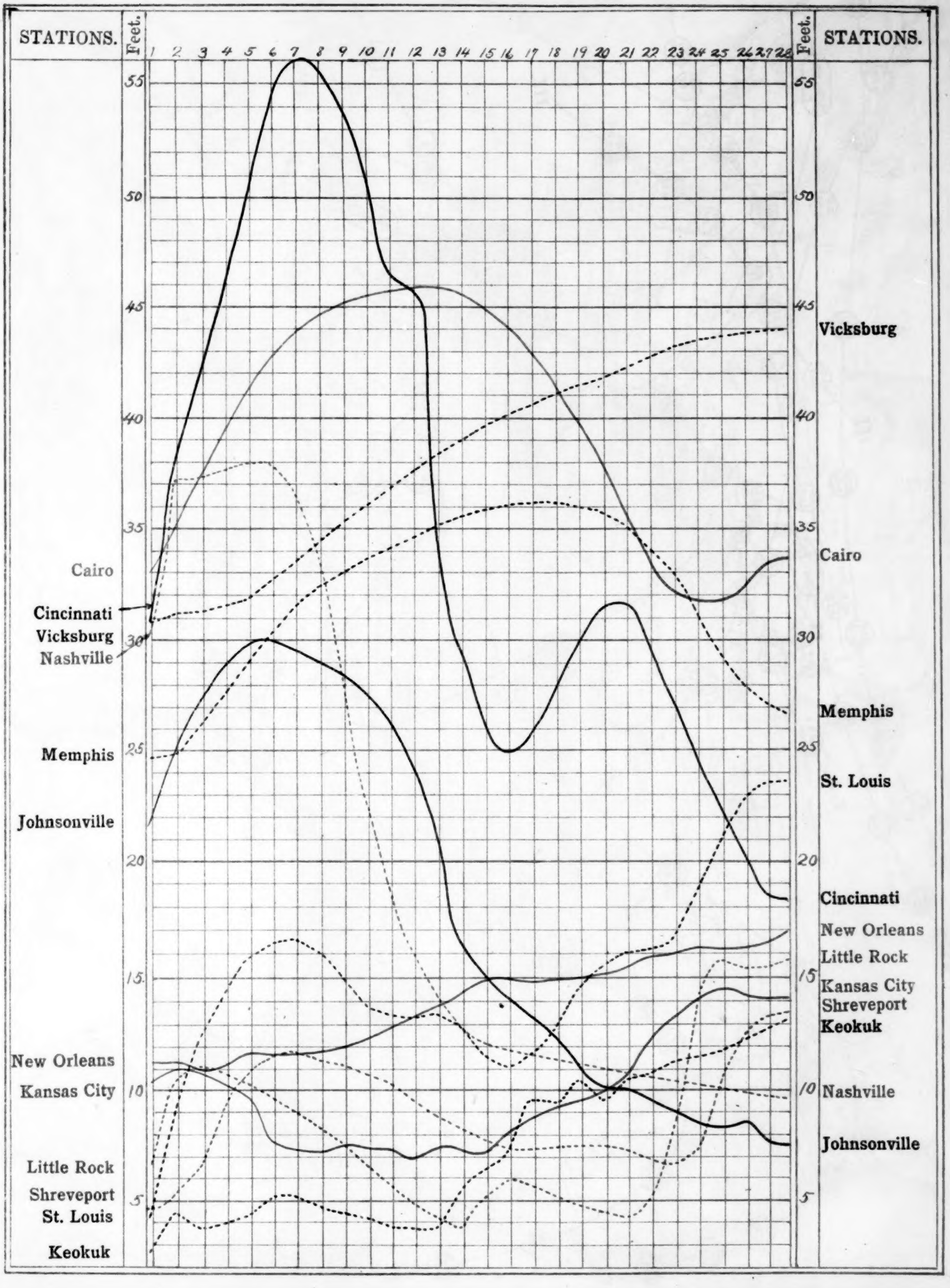


Chart II. Tracks of Centers of High Areas, February, 1915.

(Plotted in Forecast Division.)

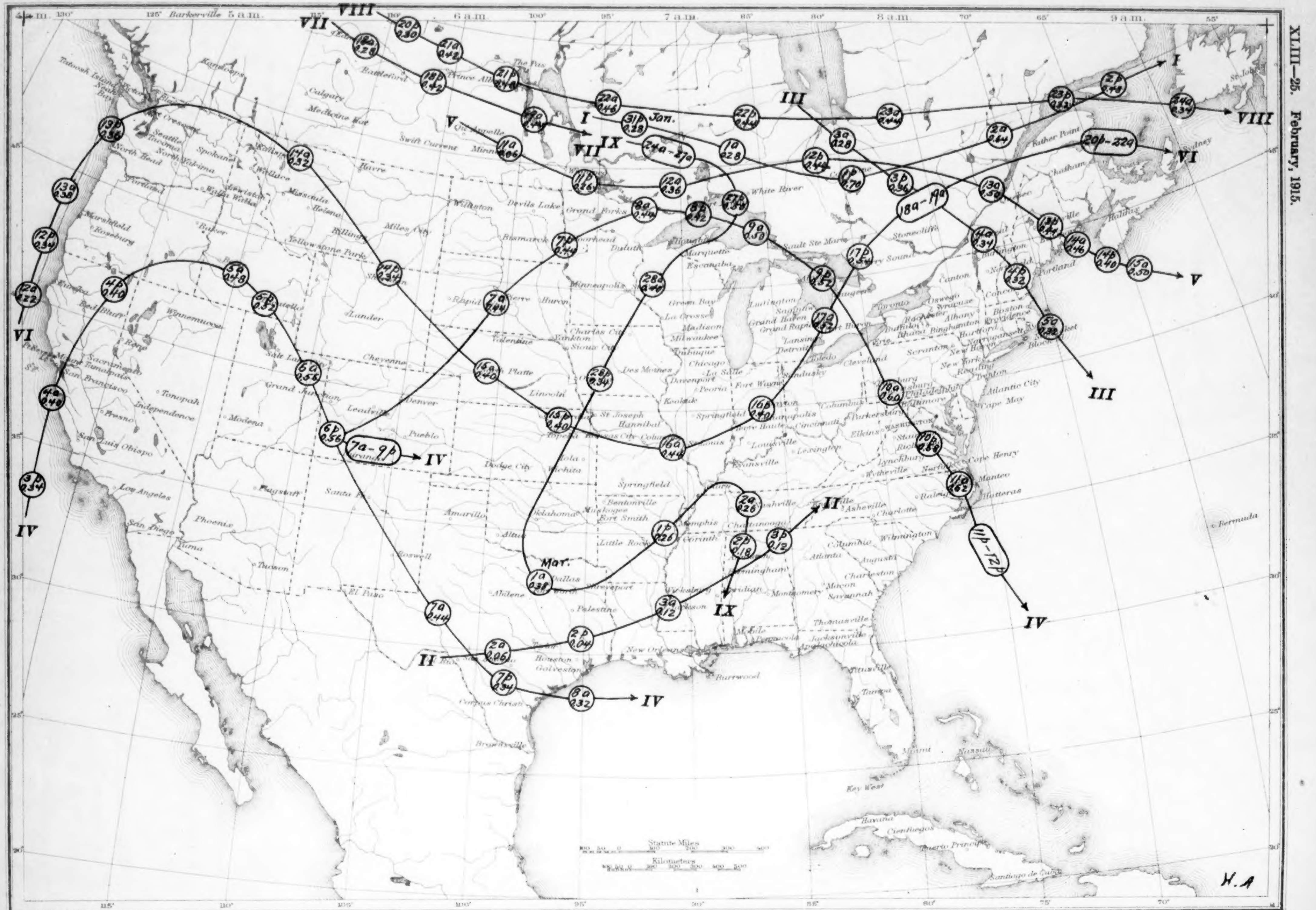


Chart III. Tracks of Centers of Low Areas, February, 1915.

Chart III. Tracks of Centers of Low Areas, February, 1915.
(Plotted in Forecast Division.)

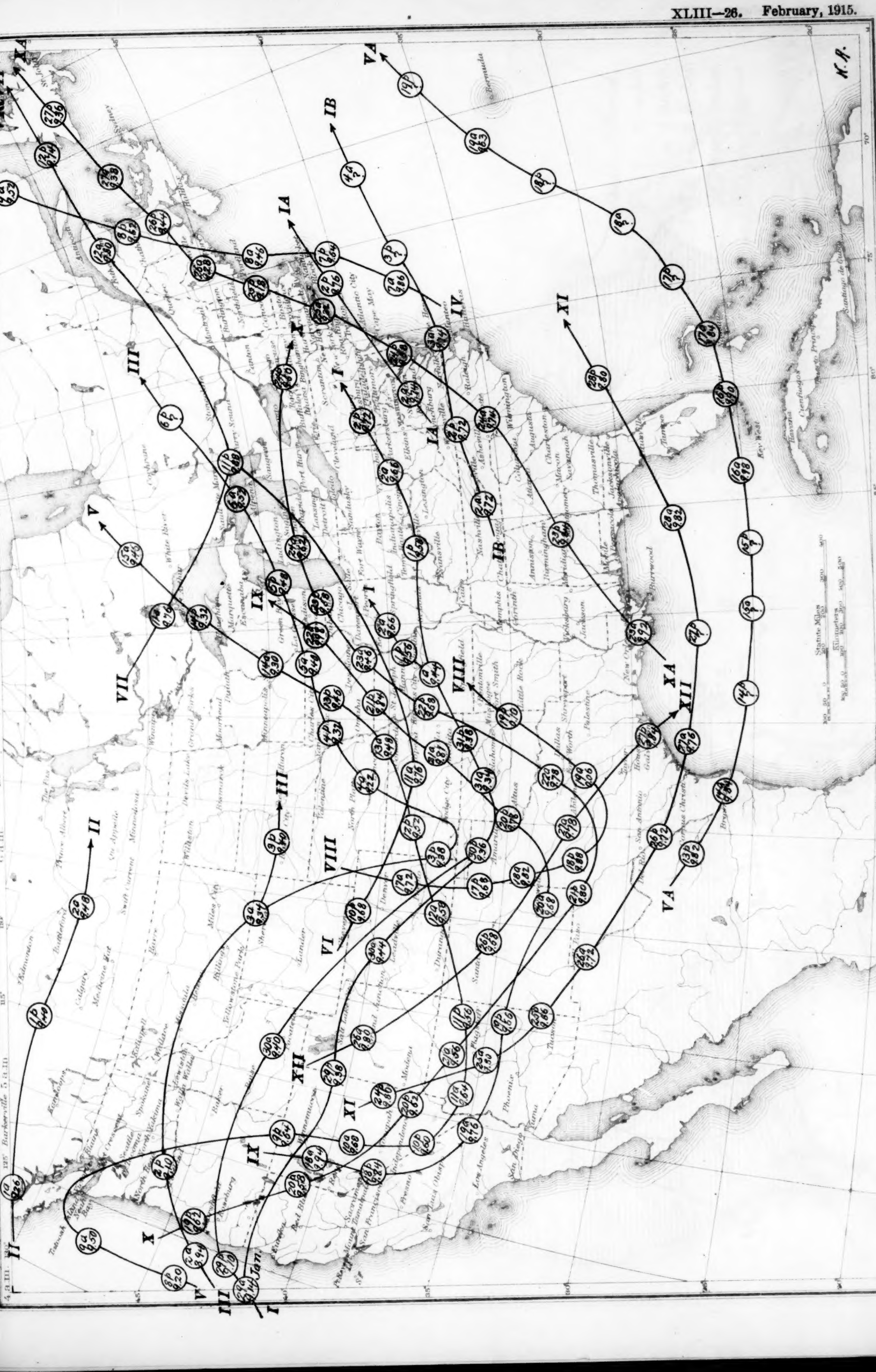


Chart IV. Departure of the Mean Temperature from the Normal, February, 1915.

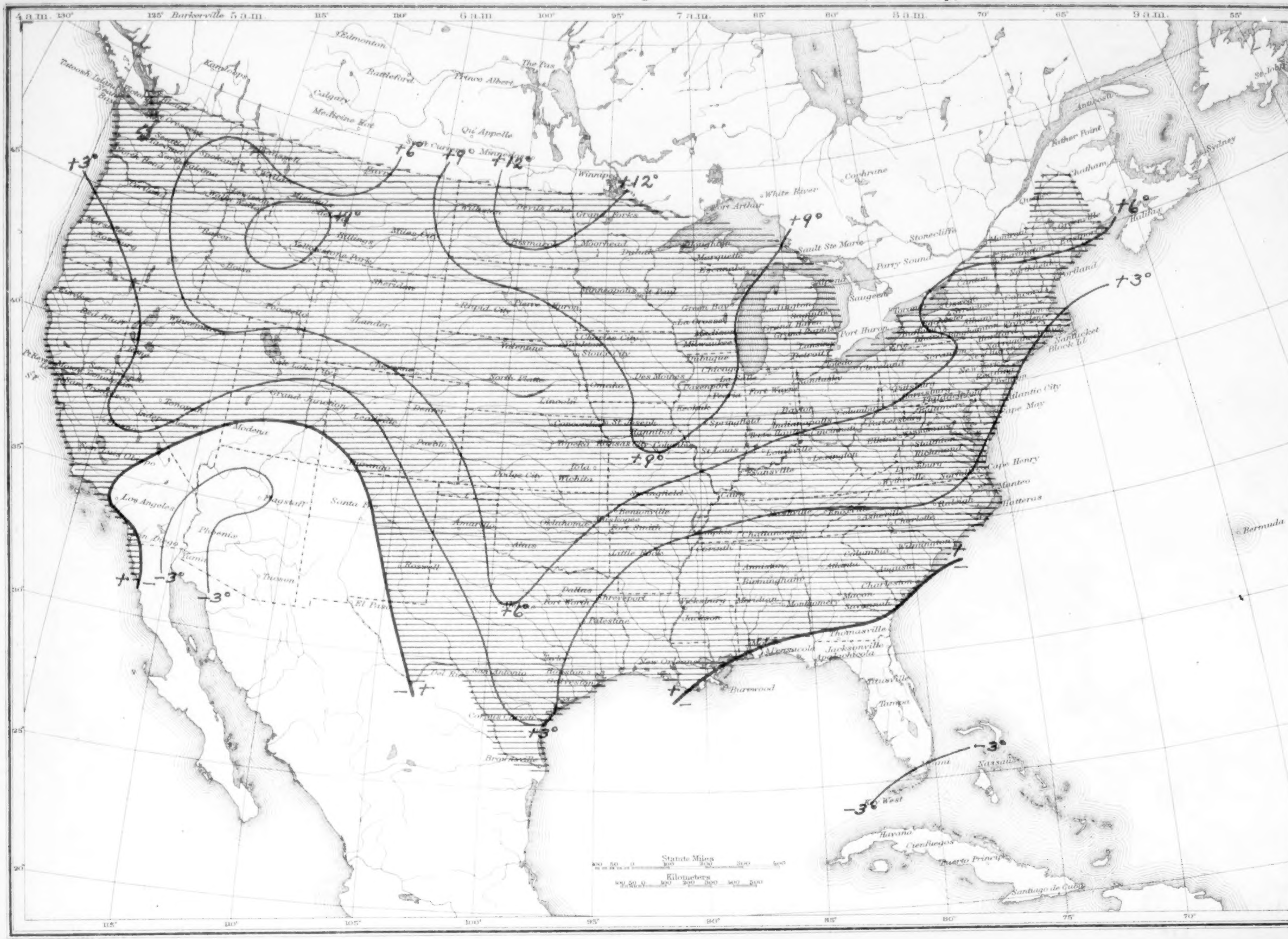
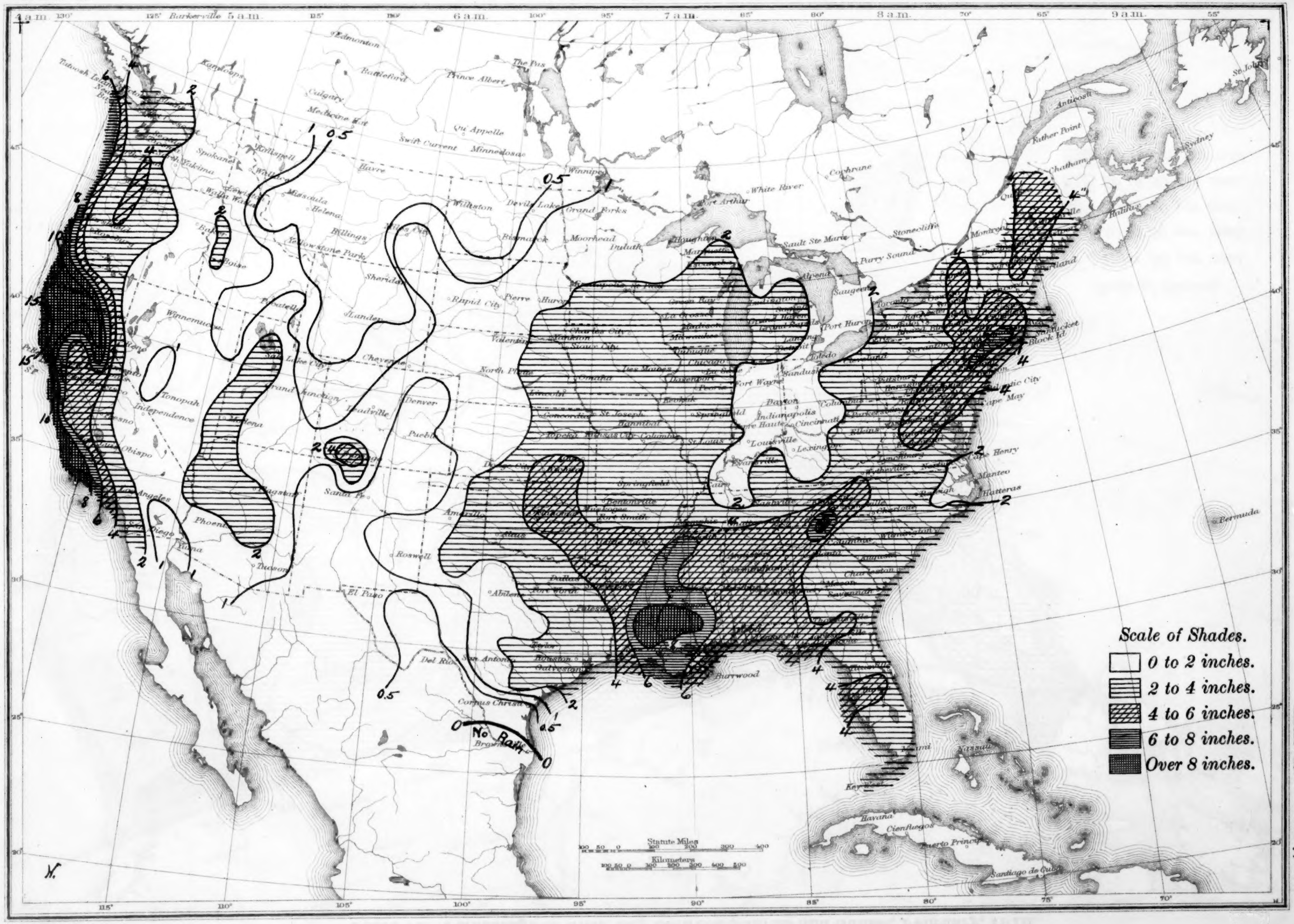


Chart V. Total Precipitation, February, 1915.



XLIII—28. February, 1915.

Chart VI. Percentage of Clear Sky between Sunrise and Sunset, February, 1915.

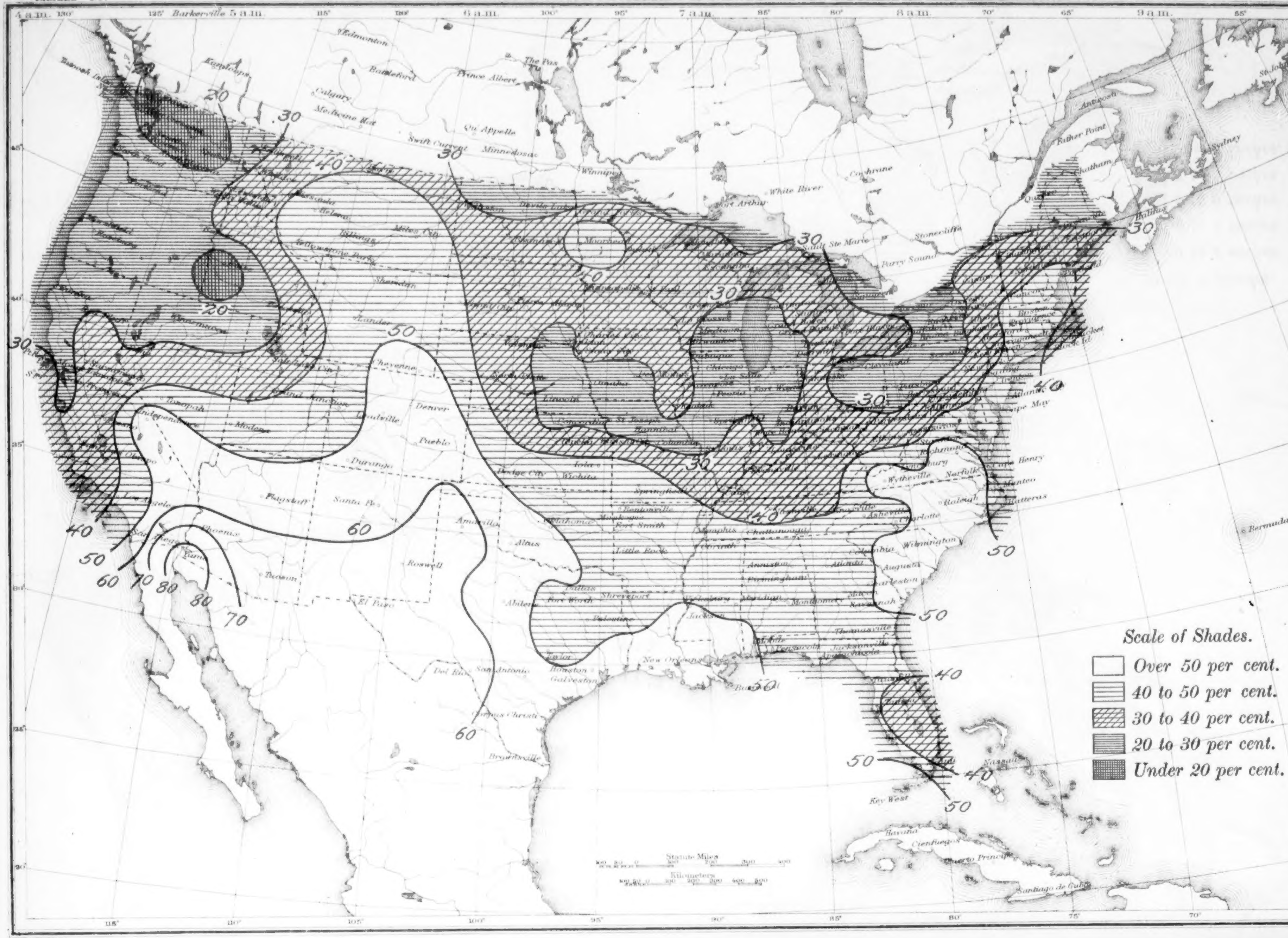


Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, February, 1915.

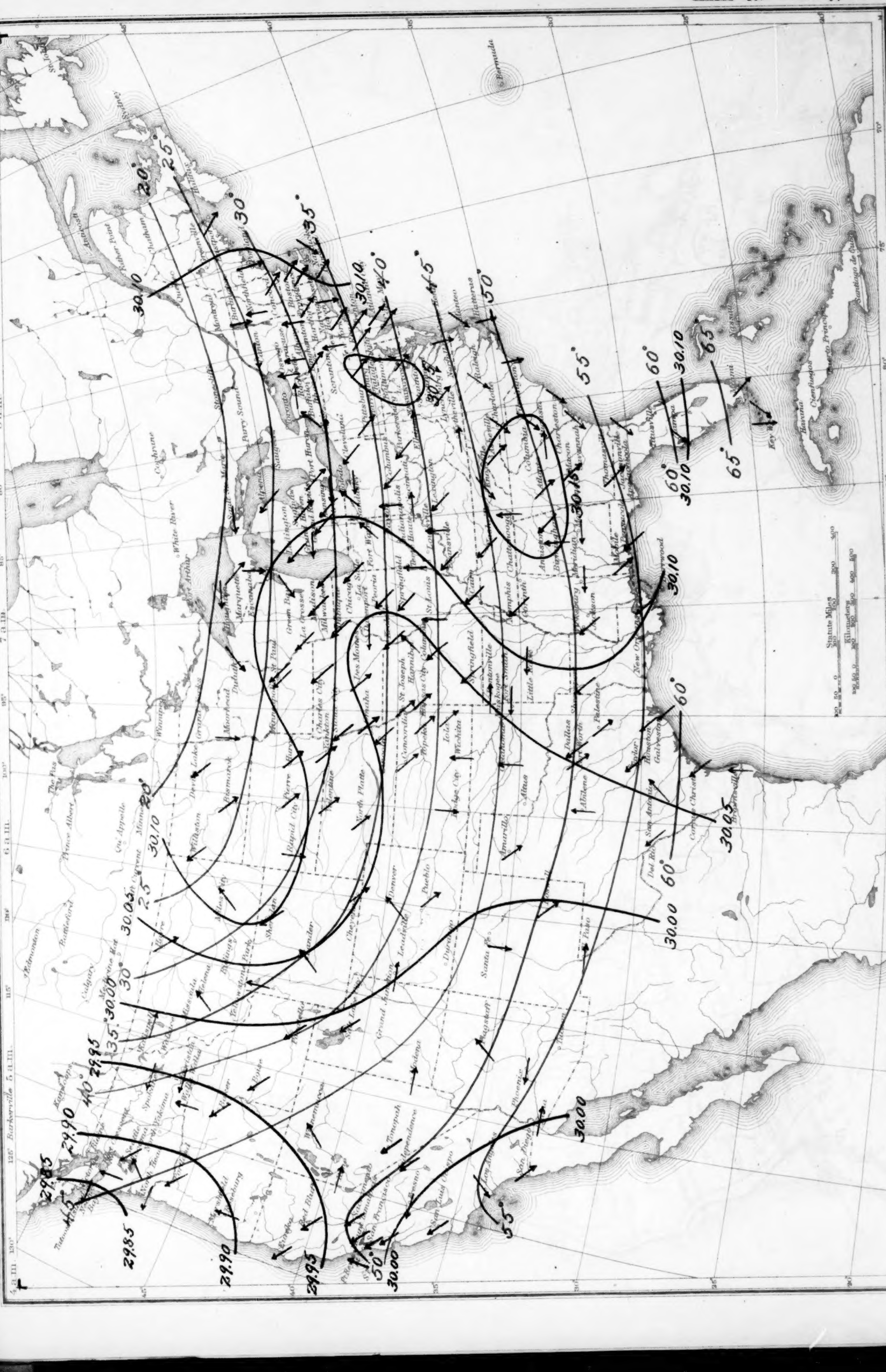


Chart VIII. Total Snowfall, February, 1915.